EVS

A CBT PUBLICATION

THE WONDER OF WATER

Nita Berry

GOLDEN SET

SKM-87

The Wonder Of Water

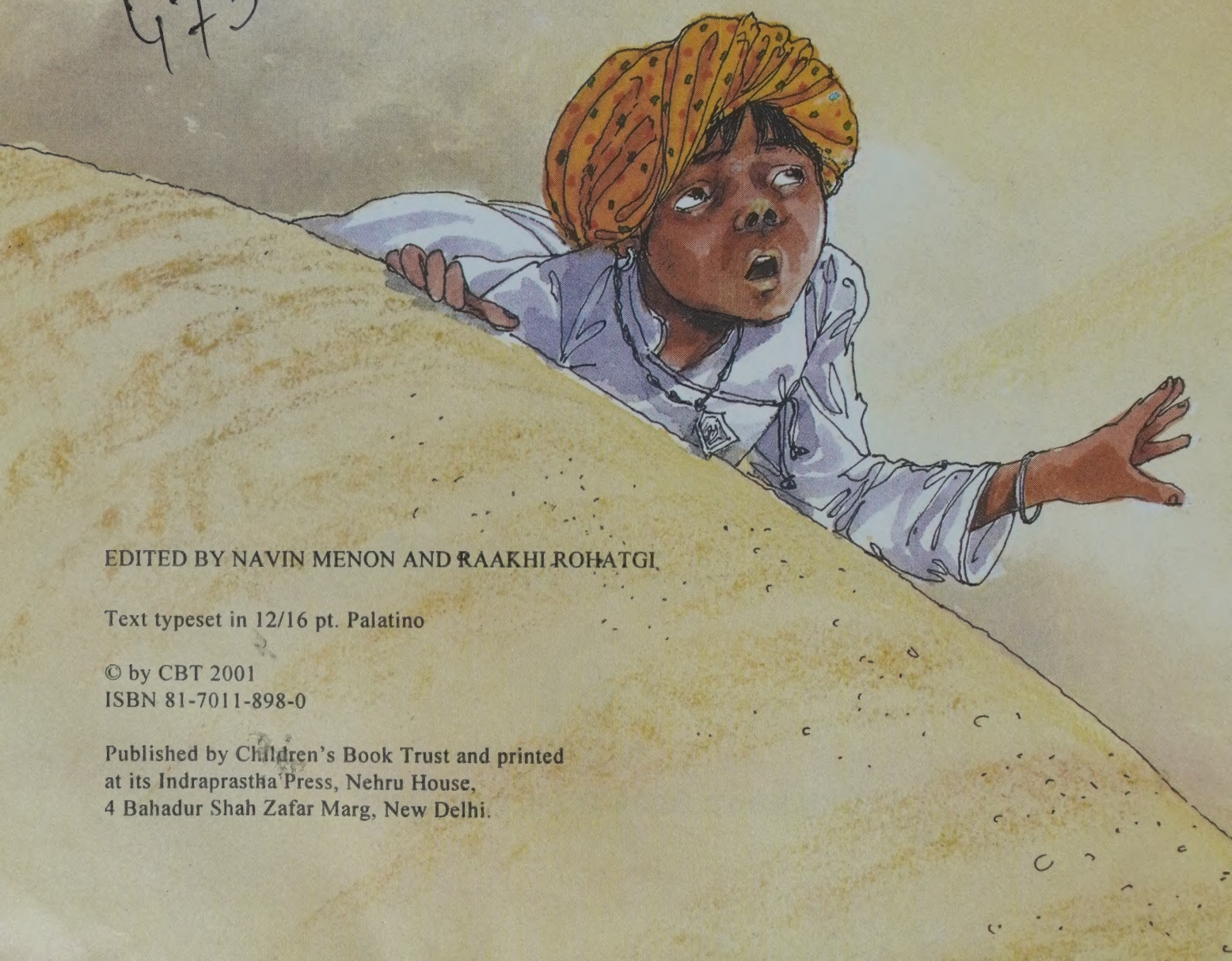
By Nita Berry
Illustrated by Neeta Gangopadhya

Children's Book Trust, New Delhi

The Wonder of Water won a prize in the category Non-Fiction/ Information in the Competition for Writers of Children's Books organized by Children's Book Trust. Apart from short stories 'The Song of the River' in *24 Short Stories* and 'Troubled Waters' in *'A Jinx on the Land and Other Stories'*, the titles by the author published by CBT are *Rajendra Prasad* and *Vinayak Damodar Savarkar* in 'Remembering Our Leaders' series and *The Story of Writing*.

SIKSHA MITRA
(Learning Centre)
Supported by : Swan rbhar

473



EDITED BY NAVIN MENON AND RAAKHI ROHATGI

Text typeset in 12/16 pt. Palatino

© by CBT 2001
ISBN 81-7011-898-0

Published by Children's Book Trust and printed
at its Indraprastha Press, Nehru House,
4 Bahadur Shah Zafar Marg, New Delhi.

Lost In The Desert

Nobody saw Ambu fall. When the storm came, his camel lurched wildly and he lost his balance in a flurry of hooves and blinding sand. How long he lay stunned on the desert sands, he never knew. When he opened his eyes, the hot dust had settled and the sun was well up in the yellow sky.

Ambu had not wanted to come on this camel trek with his cousins. It was a dreary march across the dry wasteland carrying heavy loads of water. He had been woken rudely at the crack of dawn to load big leather water-bags on to the camels.

"Your brother, Suraj, is unwell," Father had brusquely explained. "Take his camel along with Panna and the others. The bags are to be carried with good care across the sands to Rajpur. Remember, son, water is the most precious thing in the desert."

The sun beat down on Ambu as he raised his head gingerly. He was half-buried in the sand. Was the stinging sandstorm over? He remembered how a red cloud had appeared in the sky out of nowhere

and had grown bigger and bigger. He had unwound his turban hastily to wrap his face. A great rush of wind had whistled past like a lashing whip. To Ambu, it had seemed like the end of the world! Then he had blacked out.

A feeling of relief swept over him. He had had a nasty fall from the camel, but he was alive. 'I thought I was being blown to bits! Surely somebody must have seen me fall down...' Ambu thought aloud. 'I will be picked up soon for sure.'

Slowly he tried to sit up, but his head swam and every limb ached. He groaned. His shirt, ears and nose were full of sand. There was grit even inside his mouth. He spat it out in disgust. There was no water anywhere to rinse his mouth with. Ambu struggled painfully to his feet and began to dust himself.

The gleaming white sands stretched for miles and miles, as far as the eye could see. Apart from the prickly dry scrub and a few thorny bushes, there was not the slightest sign of life. Ambu was alone in the middle of nowhere.

'Where am I?' He licked his lips nervously. They were parched and his throat was dry. 'I must get back home,' he whispered hoarsely to himself. It might be a long while before the others found him or even noticed that his camel was riderless. He must find his bearings and begin walking. Ah...what would he not do for a cool draught of water!

Shading his eyes, Ambu anxiously looked around. There were no landmarks in sight. Nothing but a vast stretch of sand. He pursed his lips grimly as he looked upwards.

'Not a cloud in the sky,' he shook his head as he wiped his brow. 'This surely is one of the hottest days of the year!'

The overhead sun glared down fiercely as though it would burn him up. It seemed quite impossible to find any directions. Hazarding a guess, Ambu began a painful limp across the trackless desert. Where was water to be found?

He thought wistfully of the big water-bags he had loaded onto the camels that morning. There were two on each camel—one on either

side. There must have been loads and loads of them! How difficult it was to carry water to the Rajpur hutments on the other side of the desert!

His own village stood around a small spring. Sometimes, its waters gushed out with great vigour—enough to give them a good crop of bajra. Often during the long, dry summer, there was not enough water in the pond for even a small splash with his dog, Kalu. Why could the people of Rajpur not look for their own water? Ambu fumed helplessly.

The throbbing in his head made him more and more irritable. He was mad at everybody now—mad at his father for making him come on this tiresome trek, mad at the ungainly camel that had thrown him off, mad at the people of Rajpur... They were all to blame for his terrible plight.

The sun was beginning its descent in the cloudless sky. Ambu thought hard and tried to recover his bearings. He must move towards the north if he were to get home. His feet were sore. He was close to tears. Why did Panna not come? Was nobody looking for him? He wondered.

A big hill loomed ahead. 'I might get a wider view of the desert from the top,' he reasoned as he took a deep breath and began to climb. It was difficult to find a foothold on the slippery sand. Soon his legs were aching and giving way. His lips were cracked and bleeding. He was half-mad with thirst.

At last the intense heat of the day lessened. A chill began to steal over the desert as the shadows became longer and the sun set in the horizon in pale colours. Ambu shivered. He was alone in the dark. And he knew it could become very cold at night. What a long day it had been!

Night fell and the moonlight painted the rolling dunes in silver and black. Exhausted and hungry, he fell beside a thorny clump and drifted into a dreamless sleep.

He must have been asleep for a long time, for when he awoke the sun was high in the sky. His throat hurt with a terrible dryness. With

dismay Ambu realized that it had not been a dreadful nightmare. He was still lost on the desert sands without a drop of water. He scanned the horizon in vain. Did anybody even know that he was lost and dying of thirst? Perhaps nobody cared!

Suddenly his eyes lit up. He blinked hard. For there, far away near the horizon, where the sand shimmered gold, he could see groves of trees. And he could see water with waves! Was it possible? Could it be true? He stared as the waves moved up and down. Water! Ambu tried to run, but his knees buckled under him and he fell.

He was in a huddled heap when they found him, unconscious and burning with fever. They wetted his swollen lips and his hot face.

"Ambu! Ambu!..." He heard the faint voices become louder.

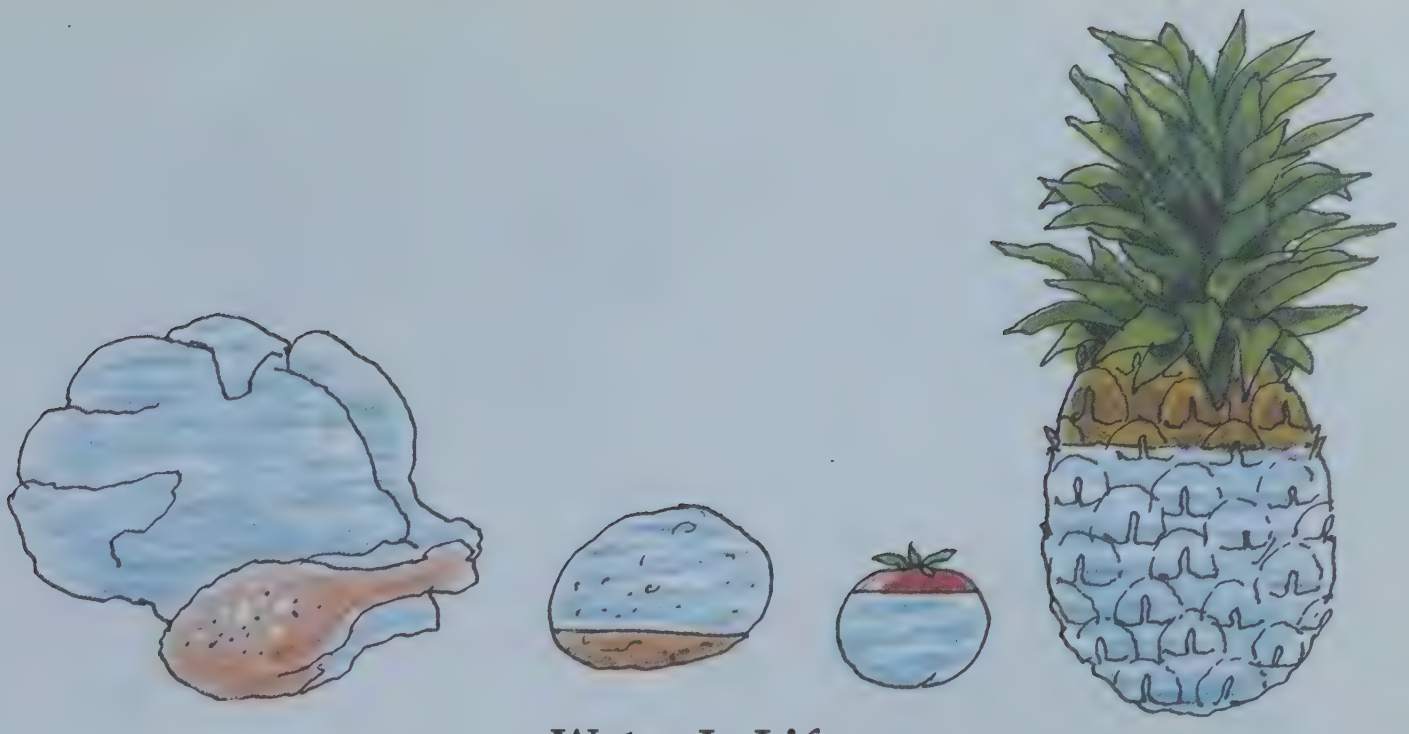
'*Ambu?* Water!' His name had never sounded better to his ears. He hazily remembered Ma telling him that Ambu meant water! Water that was precious and life-giving!

"Ambu! I am here. Wake up!" his father implored. "Thank the good Lord, we have found you. The desert can be cruel, son, even to its own people. I dread to imagine what could have happened had Kalu not found you!"

Ambu stirred as Kalu fondly licked his face. Half-opening his eyes, he managed a weak smile at the anxious faces over him.

He did not know why his thoughts drifted in a jumble to the people of Rajpur. How anxiously and how long they wait for the water-bags to arrive by camels! Now he understood why.

"Water!" he whispered, then sighed in relief as he sipped slowly, thank God for water. "Father, you were right! Water is the most precious thing in the desert. It must be shared, for it sustains us!"



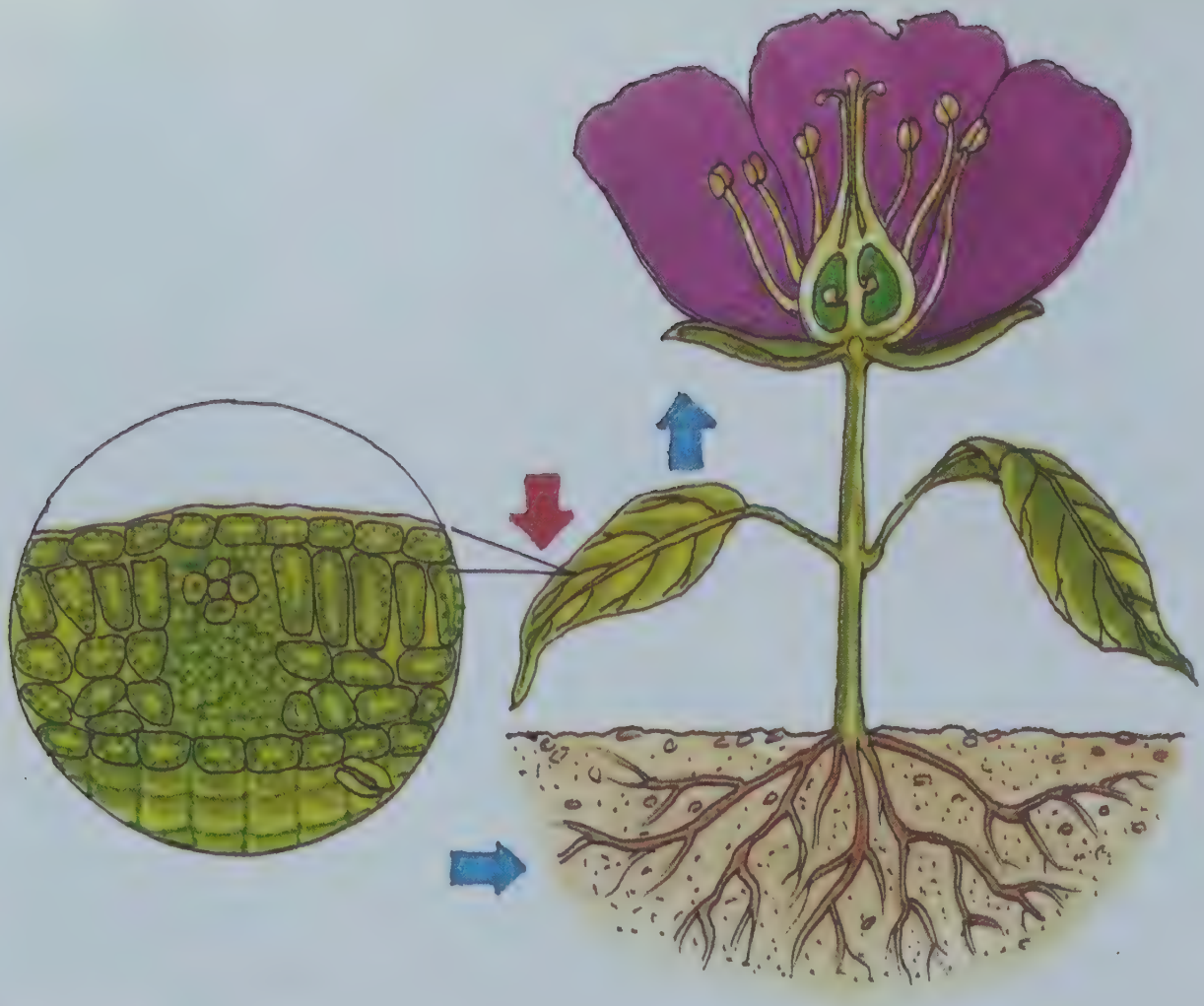
Water Is Life

Ambu was lucky to have been rescued. It is unlikely that he could have survived in the waterless desert for more than four days. Water is indeed our most precious drink. It is vital for our survival. It is grim but true that if the body loses more than 20 per cent of its normal water content, it dies painfully.

We need water as much as we need air in order to live. We can go without food for perhaps four weeks, but not more than four days without water. Water is life, for us and for every living thing on earth.

You may be surprised to know that all living things consist mostly of water. A chicken is about 75 per cent water, and a pineapple and a potato are about 80 per cent water. A tomato is even more watery—it is about 95 per cent water!

Our bodies, too, are not as solid as they seem. Even the fattest boy in your class is over 65 per cent water! If you could squeeze out a human like a lemon, you would get around 50 litres of liquid! About four litres circulate in the blood vessels alone, and bathes all body cells. The amount of liquid in the blood always stays the same, no matter how much water you drink. The body behaves rather like the thrifty old man who stores his savings for a rainy day! Extra water is stored away in the intestines, the liver, the kidneys and the muscles. It comes in handy when the body begins to get dehydrated.



Biological solvent

The body makes use of one of the most amazing properties of water—its unique ability to dissolve almost any substance. It can dissolve the hardest of rocks as it flows over the earth. It also dissolves the nutrients that living things need. This makes water essential to all living beings, who use water-based solutions like blood and digestive juices as mediums to carry out their biological processes.

In course of one day, about 10 litres of water moves around inside our body, assisting every process. Our bodies need water to take in food and make use of food. For instance, saliva from the salivary glands helps you in chewing and swallowing, enabling food to pass into the stomach, intestines and blood. Very soon, the water of the salivary glands is replaced by water from nearby blood vessels.

Other solutions help to dissolve the digested food and carry it to all parts of the body. Through chemical reactions these food substances are changed into energy as well as materials needed for growth and repair. These chemical reactions can take place only in a

watery solution. Also, water is needed to carry away wastes and impurities. Water is an essential drink for plants as well. It dissolves nutrients vital for the plant in the soil. The roots of a plant spread themselves out in damp soil to take in this water. The water travels up the stem and branches into the veins in the leaves. The veins carry water to the cells where food is manufactured. Then leaves, which are the 'food factories', manufacture food from carbon dioxide and water in the presence of sunlight. This process of making food in plants is called 'photosynthesis'.

Water is thus vital to every process that occurs in human beings, plants and animals.

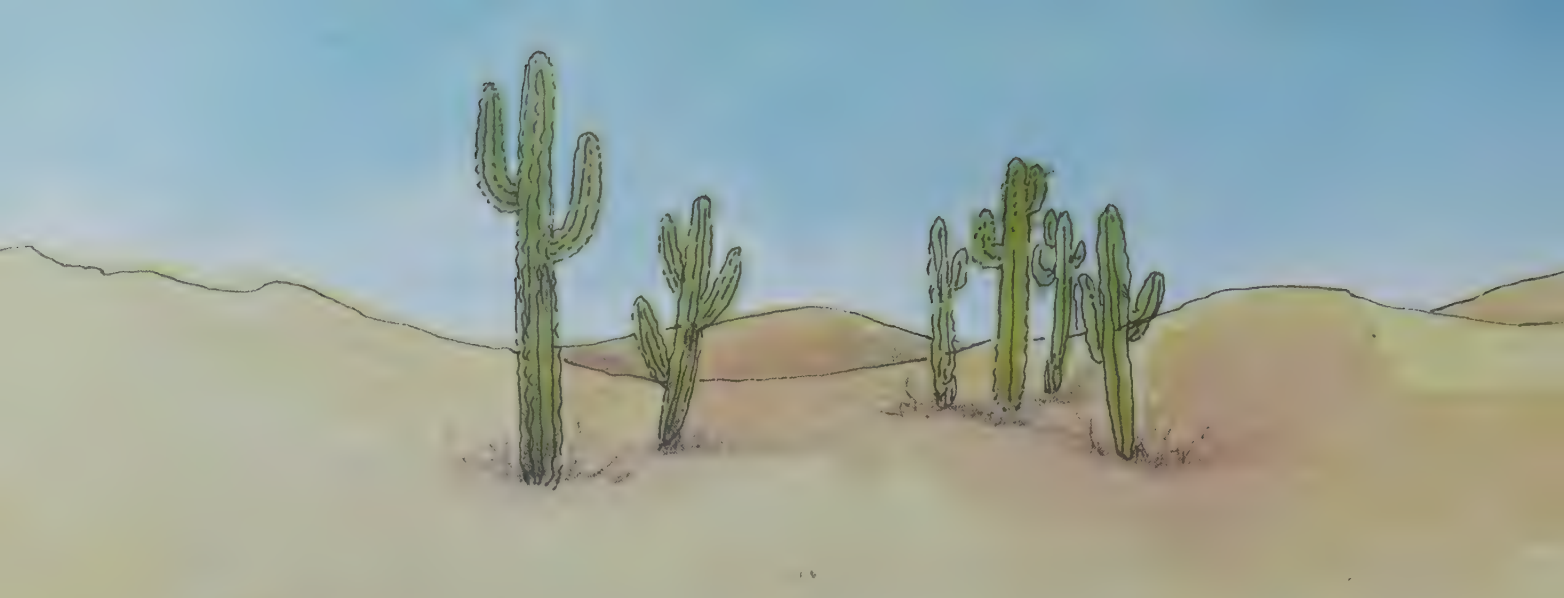
Water balance

Water is lost in many ways all the time—as sweat, in urine and in faeces, and even as water vapour in exhaled breath. A little is lost through mucus, tears and saliva, though much of the latter is swallowed and returned duly into the circulation through the digestive system.

Think of how much you sweat during a cricket match on a hot day! It leaves your clothes quite damp. On a hot day, as much as one and a half litres of sweat may be produced, mainly from the armpits, forehead, soles of the feet and palms of the hands. It is the body's most effective way of reducing its temperature.

To balance this loss of water, you feel you could gulp down any amount of water and cold drinks. These replace the fluids you have lost through sweat. Otherwise, there is every danger of your being dehydrated.

How much water do you drink everyday? To stay alive and to be healthy, you must drink about two-and-a-half litres each day in some form. Even if you drink no water at all during the day, you do take in about a litre of liquid from the food you eat. Fruit, vegetables, meat, and bread consist mainly of water. In addition, you need to



drink at least one and a half litres of water, as fluids, to maintain the level of water in your body.

Nature too finds her own amazing ways to do with a little water. Many forms of life in the desert must adapt to harsh and arid conditions here, for some deserts get no rain for years. It is not just hot deserts that are starved of water. Even cold deserts are dry, for most of the water remains frozen permanently under the soil, and plants and animals cannot use it.

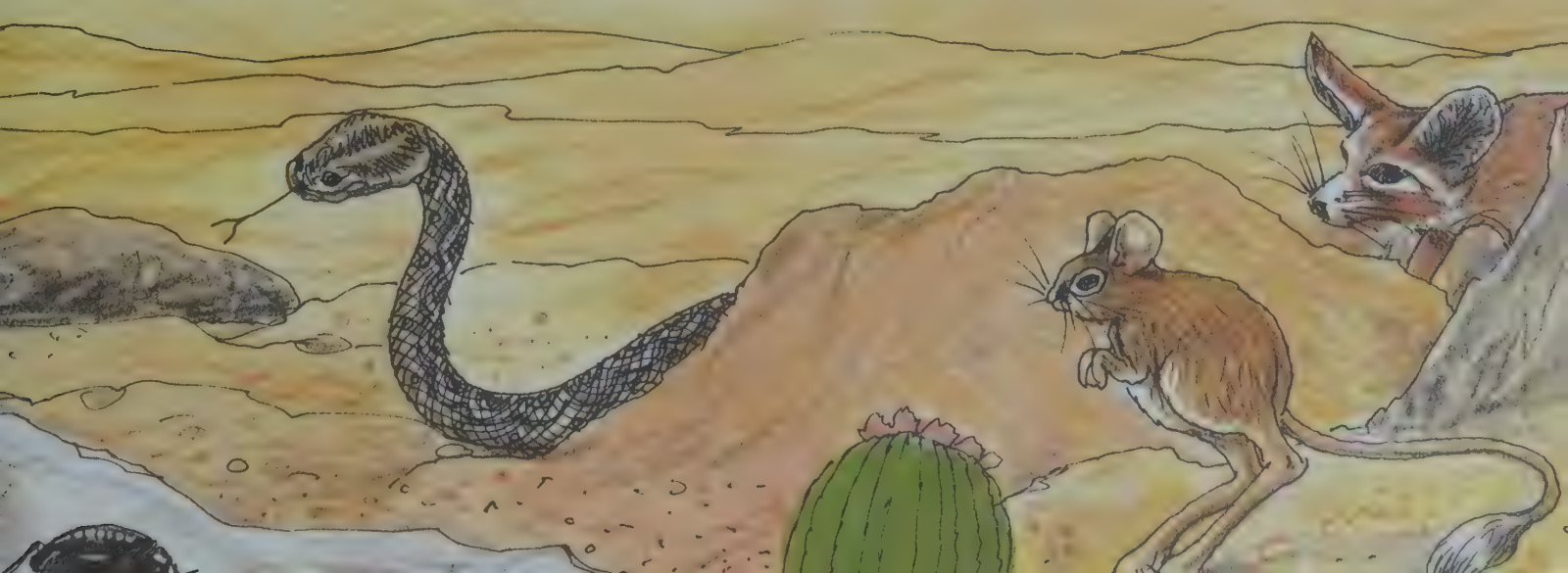
The word 'desert' comes from *desertum* (Latin) meaning 'something left waste'. Did you know that the world's deserts cover almost a quarter of the total land surface? Yet only five per cent of the earth's population lives in them. As we saw earlier, life in the waterless desert is indeed a difficult struggle. It is no wonder then that it is so deserted!

Desert shrubs make efficient use of every drop of water in the most marvellous manner. Most have little or no leaf surface. A layer of wax on the leaves prevents excessive evaporation of water from the plants. Some shed their leaves in bad conditions. Common desert

plants like cacti have an extra-thick waterproof covering. They store water in the tissues of their thick, fleshy stems and shrivel as this is used up. They grow long roots to absorb the limited moisture in the soil. The mesquite bush of the American desert gets water by sending its roots over 50 metres deep to where the soil is always moist!

Desert plants usually lie dormant during the dry or hot season, or drop seeds that can survive this period. These seeds quickly germinate when any moisture is available. They grow into plants that flower rapidly and drop more seeds. The plants are now ready to survive the long, dry season.

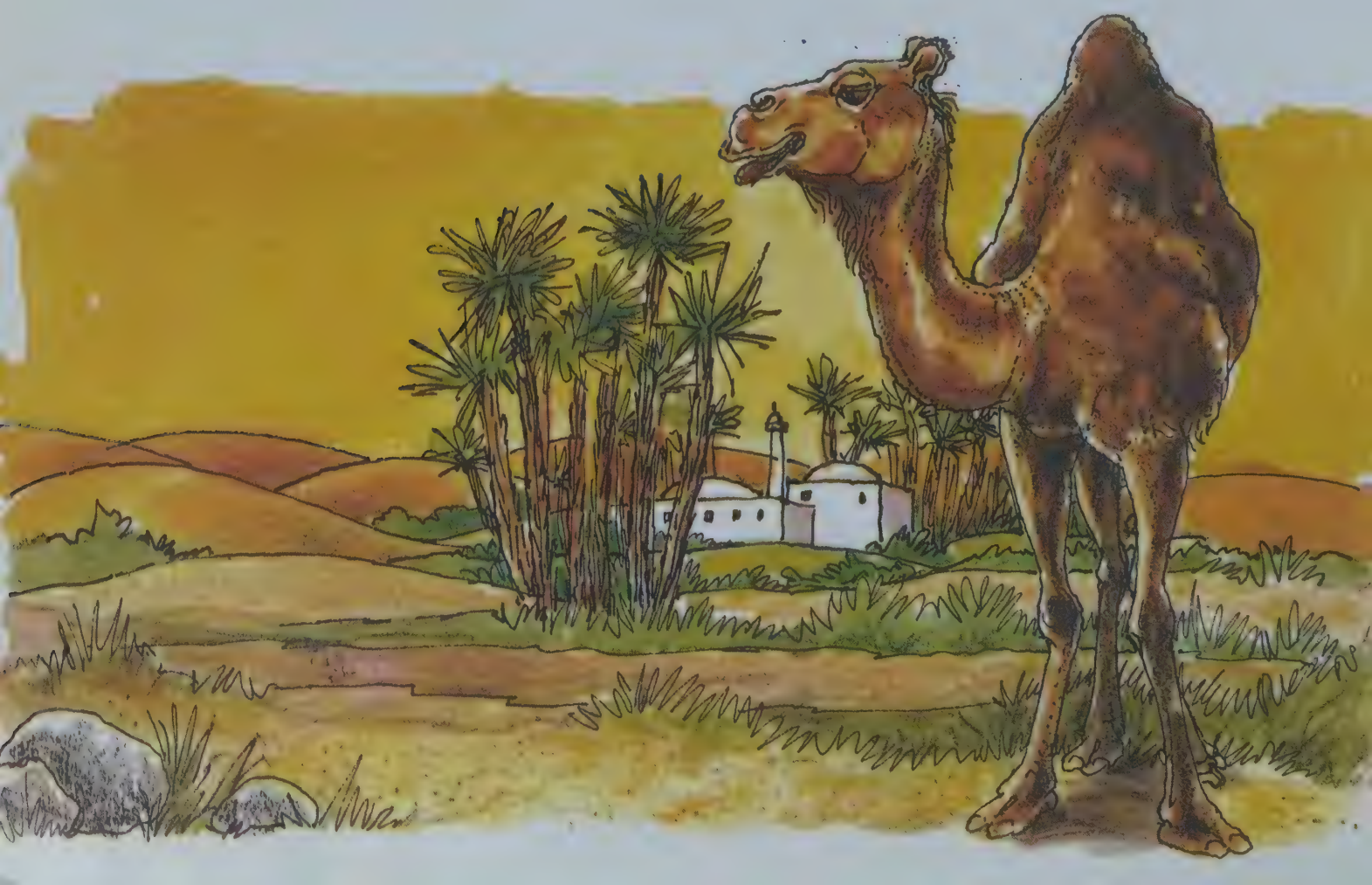
Desert creatures, too, must do without water for long periods. The hot and dry conditions do not bother the sturdy camel which is built for the desert. It survives by drinking vast quantities of water, as much as 120 litres at a time, before an arduous desert trek! Many of the smaller desert creatures do not need water at all. They get whatever liquid they require from the sap of plants and from the night dew on leaves or stones.



In such arid conditions, is it any wonder that desert folk regard an oasis as a gift of God? Many tribal wars were fought for the possession of these fertile spots in the desert. An oasis, like the one in Ambu's village, occurs at points where an underground spring of water rises to the surface. It could be small, just enough to support some plants and trees, or it could form quite a large lake around which people settle and grow crops like millet and maize. Oases are important for the survival of nomads who drive their flock from one oasis to another.

Today, dams and irrigation canals have turned parts of the desert green, for desert soil is very rich in the minerals that the crops need. For instance, the Rajasthan Canal Project, the largest of its kind in the world, uses the waters of the Satluj, the Ravi and the Beas rivers to irrigate the parched lands of north-western Rajasthan. Its main canal, the Indira Gandhi Canal, is 468 kilometres long.

One day it will perhaps bring water and hope to the village of Rajpur too. Till that happens, the long and dreary camel treks will continue to be its lifeline.

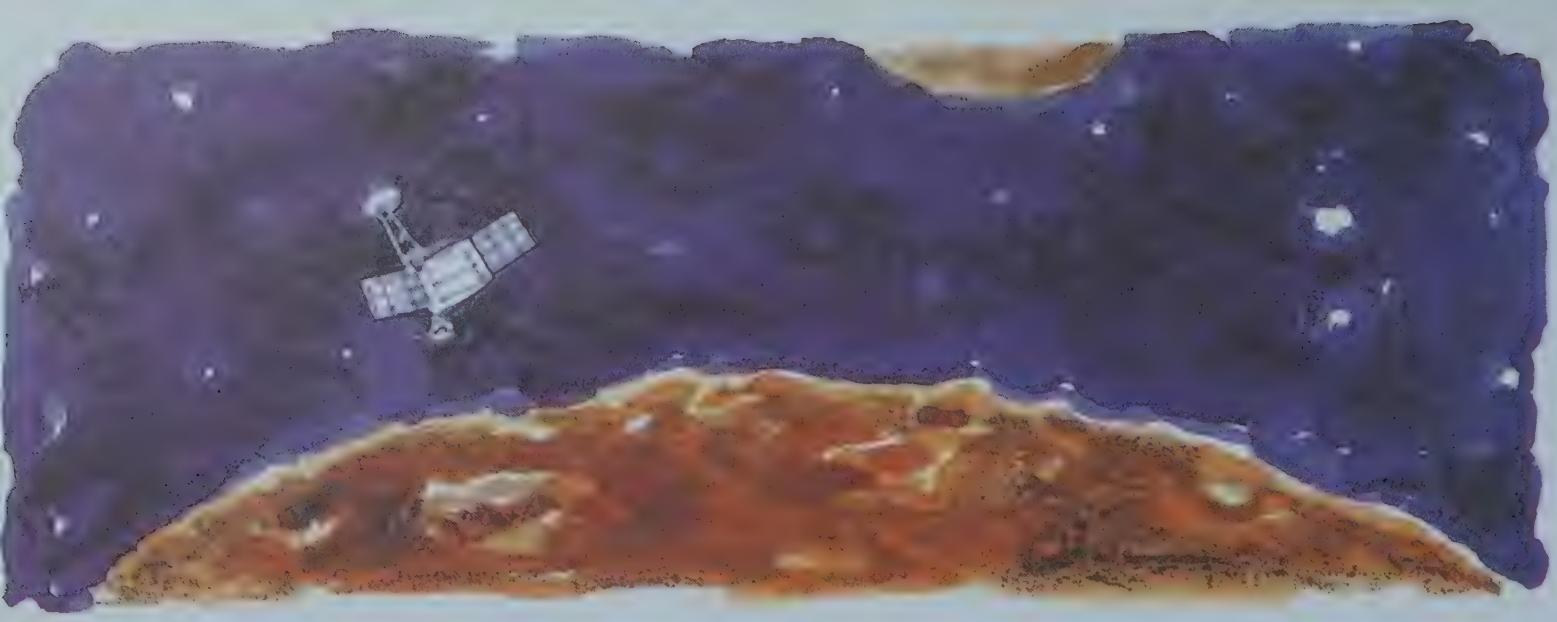


SIKSHA MITRA
(Learning Centre)
Supported by : Swanirbhar

473

The Beginning

Our planet has been misnamed. Our ancestors called it 'earth' after the soil they found all around them. For a long, long time they believed that they lived on a vast plateau of mud and rock with only small bodies of water scattered on its surface. They did know about the oceans, but regarded them as enormous rivers that ran around the rim of this plateau. Little did they realize that their home was in fact more water than earth.



The earth

Almost three-fourths of the earth is covered with water giving it the name, 'Blue Planet'. There is nothing like it in the solar system.

Mercury, the planet nearest the Sun, is dry and lifeless like the moon. Only a trace of water vapour has been detected in the atmosphere of Venus. Mars is believed to have a very thin atmosphere and a small amount of surface water, but nothing resembling an ocean. Recently, the roving American spaceship, 'Sojourner'—the first mobile vehicle to roam another planet—sent images from the Martian surface, 192 million kilometres away. These suggest signs of ancient water activity on the planet. As far as we know, however, the Red Planet does not support life. And the great outer planets—Jupiter, Saturn, Uranus, Neptune and Pluto—are really too far from the Sun to have liquid water, though possibly they have ice.

The earth is at the right distance from the Sun to have liquid and frozen water and water vapour. It hangs in space like a sapphire globe capped with ice at the poles and flecked by wispy white clouds. Our ancestors had no way of knowing this; else, they would have named our planet 'Water' or 'Oceanus'.

Even today, Ambu and other desert folk, who live where very little water exists, would find it difficult to believe that as much as 71 per cent of the earth's surface is water. In the northern hemisphere, water covers 61 per cent of the surface, whereas it is even more in the southern hemisphere—about 81 per cent!

Water seems to be everywhere. Where did it all come from?

It is difficult to solve a mystery without many clues. One must be supported by good reasoning and calculations based on the study of facts available. Scientists are rather like detectives. They have for a long time been trying hard to solve the mystery of how oceans were formed. It all happened so long ago—before life began—that there is almost no geological evidence.

The earth is much older than its oceans. It is perhaps four-and-a-half-billion years old. We are not quite sure about how it was made, but most scientists believe that a huge explosion in space, perhaps 15 billion years ago, called the Big Bang gave rise to the universe. The debris and blazing gases from this violent explosion were flung into space. These scattered, spinning clouds of dust and gas, took millions of years to cool, giving birth to galaxies and our solar system.

The earth was a spinning ball of gases with immensely hot liquid at its centre. This cooled over a period of time and solidified into our planet. The heavy materials formed the earth's core, and the lighter materials became its crust. Even now, the innermost core of the earth, which is about 5,000 kilometres beneath its surface, is as much as 5,000 degree Celsius. When you reckon that water boils at 100 degree Celsius, hot enough to burn yourself badly with, you can get an idea of how intensely hot the earth's core is.

There were probably no seas yet on the earth. These may have been created when the temperature of the earth's surface fell below the boiling point of water. Before this happened, it is likely that water vapour was trapped in the interior and was released during structural changes in the young earth. It hissed out as steam through crevices and volcanoes to form great clouds that enveloped the sky.

It is probable that the surface of the earth was so hot that, for a long time, no moisture could fall without being converted to steam immediately. This would have helped to dissipate some of the surface heat into the upper reaches of the atmosphere, and thence into space.

For thousands of years, the steamy clouds surrounded the earth and prevented the rays of the sun from reaching its cooling surface.

Rain!

One day, something wonderful happened. The falling raindrops did not hiss away into steam, but fell as rain! And how it rained and rained! The crevices and hollows of the bare planet were filled with rain-water. Rainwater seeped into the rocks. Still, the rain did not stop. Water began to accumulate in all the low-lying areas of the earth's crust, taking maybe a billion years to form the oceans.

Most scientists are of the opinion that a major part of the earth was once under water. The land and continents came up later. There is evidence to show that certain parts of the land were, in fact, once at the bottom of shallow seas. Most of the limestone, sandstone and shale found on land were deposited as ocean sediments.

Have you wondered why water in the oceans is salty? It became salty because of the disintegration of the earth's crust over perhaps

two billion years. The break-up of rocks by frost and erosion, the gradual wearing-down of mountains releasing locked chemicals that were carried by rainwater down to the ocean, and the rocks on the ocean bed—all these added salt to the sea water. The soluble salts remained in the ocean. The insoluble materials formed sedimentary rocks and the ocean sediments. This never-ending process goes on and sea water is becoming saltier and saltier!

Estimates have been made of the age of the oceans, taking into account the amount of mineral salts they hold. These estimates range between 500 million to one billion years.

Nature behaves in much the same way today. Water in the form of water vapour escapes from volcanoes and cracks on the surface of the earth. This goes into the atmosphere along with all the water that has evaporated from the oceans, and comes back into the oceans, just like the first drops of water in the beginning. This is in fact nature's water cycle, which is like a giant wheel that never stops.

The Dawn Of Life

Can you picture the earth as it must have been a long time ago—not just a few hundred or thousand years ago, but as long back in time as perhaps three-and-a-half-billion years? It was quite different from our familiar world. The land was rocky and bare, and the oceans and seas were hot. The landscape was desolate. There were neither flowers nor trees—not even the smallest blade of grass grew, for there was no soil anywhere! No birds sang in the skies and no animals stalked the land. An eerie silence pervaded the entire planet.

In water

Yet it was not completely so, for all the ingredients were there that would one day make life begin. Only the right conditions were needed for our earth to come alive!

The earth remained barren and lifeless till about three billion years ago when something remarkable happened. Life awoke! Scientists believe that this happened in the oceans when their waters were still warm. Many kinds of chemicals were washed into these waters which became a kind of sunlit chemical soup. Perhaps it was when the right mixture of chemicals took place at the right temperature and with the light available that the highly complex chemistry of life was set in motion, and the first living matter was formed.

Some scientists have now come to think that life began not in the warm oceans but in sunlit shallow pools that sometimes dried out under the fierce heat of the sun. Very simple forms of life, like bacteria, are known to dry out completely for a long time and then become active again when they have moisture. Whether it was in the warm oceans or in the small pools, life, in all probability, first took shape in water, and only after millions of years did some forms adapt to living on land.

The first living things were probably tiny one-celled organisms

which acquired the ability to make food from the chemicals dissolved in the oceans and the energy from sunlight. They lived in close clusters and reproduced by simply splitting into two.

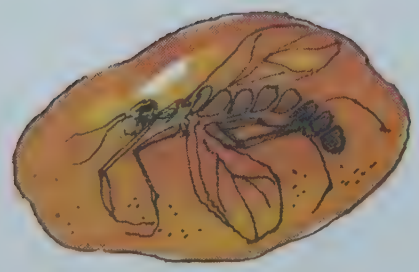
Gradually, some of the first living forms changed to become more complex creatures. Plants of many kinds developed slowly. These early plants resembled green algae and made oxygen.

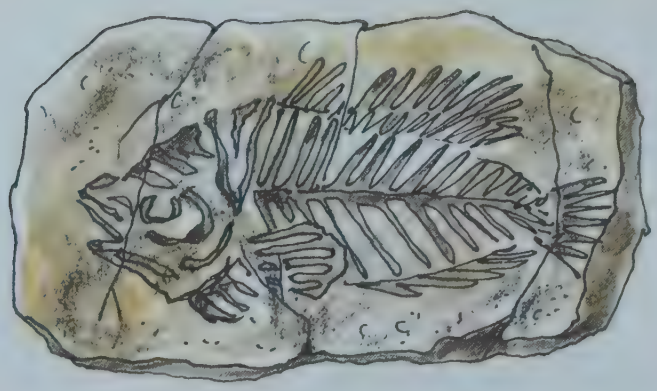
Oxygen, vital to all life, is released as a by-product by the plants during the process of photosynthesis for manufacturing their food. Plants thus help provide us with this life-giving gas.

Animals need oxygen to live. They used the oxygen made by plants. In time they developed from single-celled to many-celled forms in water and evolved organs. They were now bigger too. The earth was witnessing the miracle of a natural process—evolution.

This process of change takes hundreds of thousands of years, so nobody can watch one kind of plant or animal change into another. One may well wonder what evidence we have of all these things that happened during the dawn of life on earth.

The fossils are evidence we have that tell us about early life. They are impressions in rock of the remains of plants and animals. For instance, when a fish died millions of years ago, it sank to the bottom of the sea.





Its body rotted but the bones remained. Layers and layers of sediment covered them and this gradually hardened into rock, trapping the bones. This rock was pushed up because of the earth's movements. Wind and water wore down the upper layers, exposing the fish fossils. It had been thus well preserved since antiquity.

However, the first living forms were probably soft, like jelly, and did not leave any trace of their existence in the rocks. So we really have no clue about the exact period in which they appeared in the water. It was only when animals with hard shells, bones and teeth evolved that their fossils gave us a good idea of what these long-vanished creatures probably looked like.

From sea to land

Meanwhile, many strange and wonderful things were happening on our planet. A great upheaval in the earth's crust, about 435 million years ago, lifted many parts of the ocean bed out of the water, creating mountains. Many sea plants which had not evolved very far in the sea were suddenly exposed to new conditions. They had to transform themselves to survive, and some kinds may have died in the process. However, others began to evolve rapidly on land. It is an interesting fact that even today, most marine plants are quite primitive and may not be very different from the ancient forms.

Many plants began to spread on to the land. They gradually reduced their dependence on water and were able to survive in drier

places, adapting their structure and behaviour to suit available conditions to the full. In course of time, they thrived. In about a hundred million years, tiny plants had reached enormous proportions to form the first forests on the highly fertile ocean beds that had risen out of the water. The land was now green with vegetation, and ready to support the first animals with food and shelter.

The first land animals were nothing spectacular. They were probably cockroaches, scorpions, spiders and millipedes—all descendants of the sea scorpion. The early cockroaches were perhaps the first creatures to try their flimsy wings. Other little creatures soon followed suit and learnt how to fly.

The oceans were full of strange dwellers 350 million years ago. Some had protective shells, like the giant nautiloid, an enormous snail with long tentacles. Others had developed simple lungs, and could, with time, crawl on to land if they wanted to.

The arrival of the vertebrates, that is, creatures with backbones, was a landmark. This meant the start of more highly developed

animals—a process that ended with the coming of man. Vertebrates too first appeared in the sea. A few came ashore and stayed there, developing into the first land-dwelling vertebrates. Man is said to have descended from one such land-invading vertebrate.

Amphibians had left the ocean for land, already living most of their lives in swamps where huge ferns grew. However, they did go back to water to lay their eggs. The name 'amphibian' is a very descriptive

one, coming as it does from a Greek word meaning 'leading two lives'.

It was about 180 million years ago that gigantic reptiles called dinosaurs stalked the land. Equally large reptiles, the plesiosaurs lived in the seas. They were enormous creatures, some growing up to 13 metres long. It was easy to sweep their long necks through the water and snap up fish and other sea creatures with their sharp teeth. However, the fastest swimmers in these early seas were the marine reptiles called ichthyosaurs.

In this planet of strange creatures, human life was still a very long way away. Most mammals evolved only after the large reptiles became extinct. Man is among the newest mammals. And modern man appeared no more than 150,000 years ago. He is the most advanced creature in the long and complex line of evolution.

Before the coming of the large reptiles, the continents were believed to have been all joined together as one land mass—a kind of super-continent called Pangaea. One ocean covered the rest of the earth—the Panthalassa. Slowly the land masses began to break up and drift apart. New oceans formed as the continents moved away.

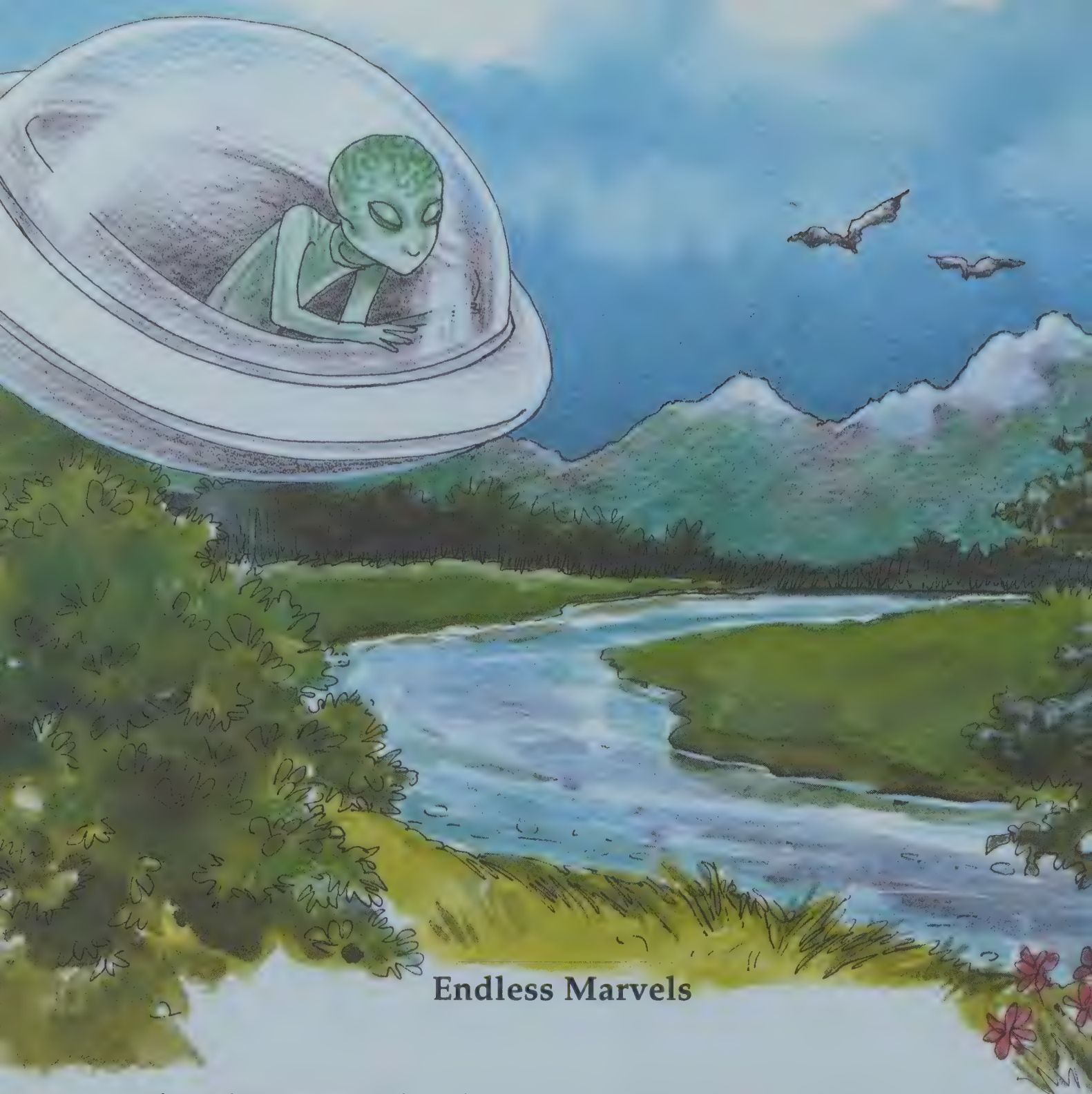
A million to 10,000 years ago, huge areas on earth were periodically covered with ice. These were the Ice Ages. Later, when much of the earth became warmer, humans began to settle down at last and grow food.

The process of change on earth has not stopped. The oceans keep changing. The Atlantic Ocean grows by a couple of centimetres every year, whereas the Pacific is shrinking. This ocean covers nearly one-third of our earth's surface—all the continents would fit into it, with room to spare!

Watery abode

Water provides more than a hundred times more living space than land. From the sunlit surfaces of shallow waters to murky depths of several kilometres in the great oceans, it simply teems with life. Tiny one-celled plants live alongside huge fish and aquatic mammals. Life here is an unending struggle for survival. For every living creature, plant or animal, the problem of staying alive is the same—finding something to eat, and to avoid being eaten.

The ancestors of today's countless living things in the oceans and on land were the first tiny creatures in the waters. These waters, which have been called the 'cradle of life', have truly made the earth a remarkable place. As far as we know, nowhere else in the solar system, or even beyond, does such a complex web of life exist.



Endless Marvels

If an alien were to drop by on the earth, he would surely exclaim, "How different the beautiful 'Blue Planet' is from its companions orbiting the Sun."

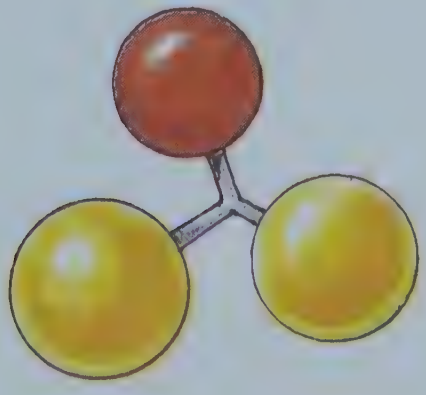
The rain that falls, the rivers that flow, and the invisible water vapour in the air are unique and life-giving. If there was no water on the earth, it would be as lifeless as the moon. To the alien from outer space, it might even seem to be magical, for nothing else in our knowledge can achieve all the marvels that this colourless, tasteless and odourless liquid can.

To understand the magic of water, we must look at the building blocks of the universe. These are particles called atoms which are too tiny to be seen but which make up everything around us. Atoms are usually joined into little groups called molecules. These never keep still, but vibrate backwards, forwards and sideways all the time. They vibrate gently even in solids, though they are packed together tightly in a neat pattern and do not lose their place. This is why a solid has a definite shape.

Scientists found out that water is made up of atoms of hydrogen and oxygen, two gases which are found in the atmosphere. The water molecule consists of two atoms of hydrogen and one atom of oxygen. This gives us its chemical symbol, H_2O. Like all other molecules, the water molecules are also always moving.

Even the purest water contains substances apart from hydrogen and oxygen. However, these make up only a small fraction of its composition. In its natural state, as river, pond or sea water, it contains a variety of dissolved minerals and salts.

Like other chemicals, water can exist in three states. This means that it can be a solid, a liquid or a gas. It can change from one state to another depending on its temperature and pressure. Heat is always produced or lost during these changes. No other substance appears in these three forms within the earth's normal range of temperature.



Life-friendly

Water is an odd substance in many ways. In most substances the liquid takes more place than the solid because the molecules are farther apart—remember they are packed tightly in solid substances. When water gets colder it freezes at zero degree Celsius into its solid form, ice. The molecules in ice are far apart and almost motionless. Ice therefore takes more space than water. And it does not expand by just any measure—it expands by about one-ninth of its volume.

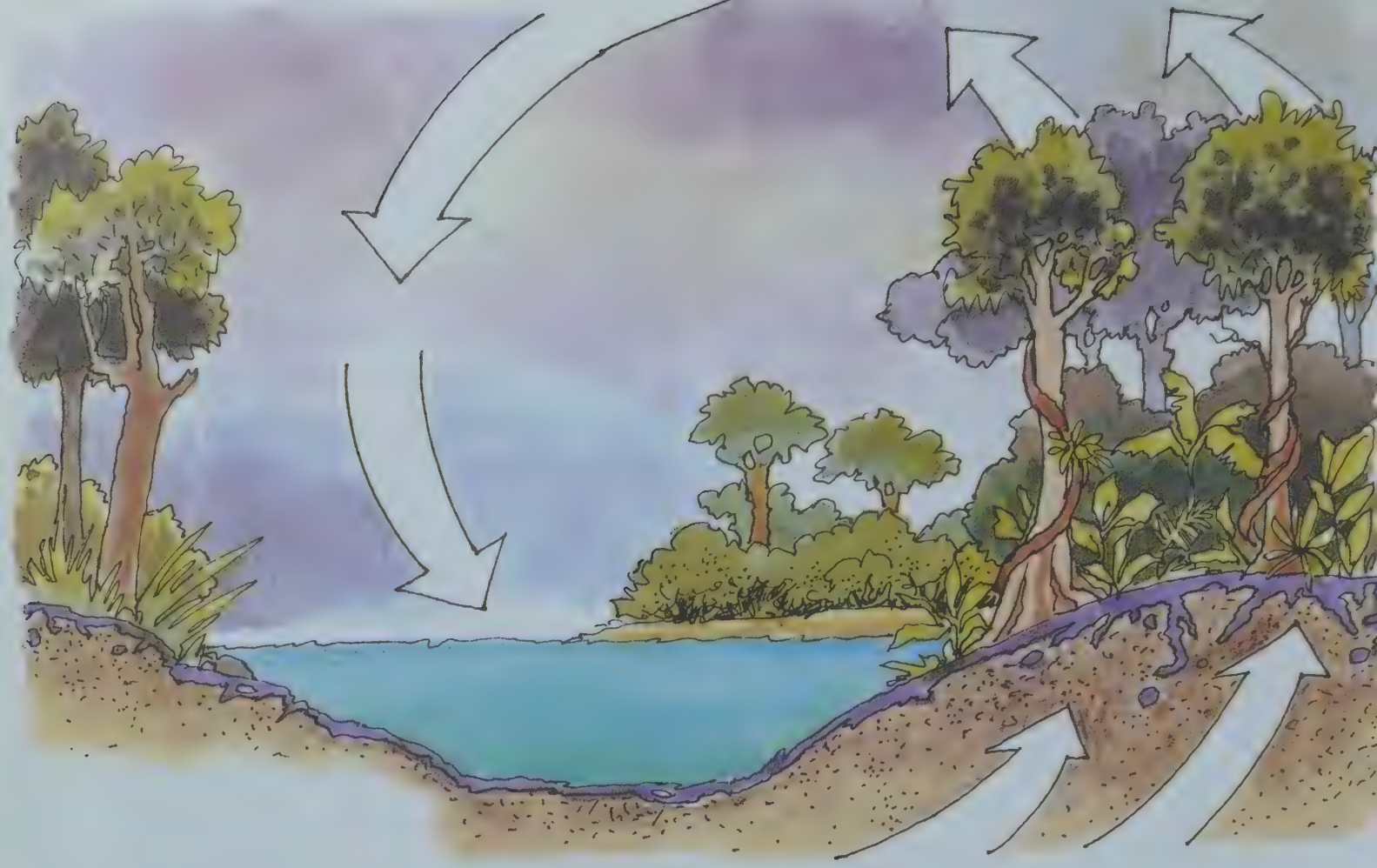
So if you freeze nine litres of water, you will have ten litres of ice! That is why pipes can burst in winter if the water freezes in them, for it expands and makes them crack.

As ice is less dense than water, it always floats on water. Just as ice cubes float on the top of your cold drink. Big bodies of water never freeze solid. The ice sheet on the top protects the water below. For instance, the depths of the cold polar seas remain unfrozen, enabling the creatures that live in them to survive.

This peculiar property of ice is actually a life-saving one. If water contracted on freezing, like other substances do, the ice formed would be denser than its equivalent quantity of water. Can you imagine what would happen to all the ice that floats on oceans and seas in the frigid zones? Naturally, it would sink. Each winter, more and more ice would accumulate at the bottom of the oceans, lakes and rivers. Even the sun's heat in summer would be unable to penetrate deep enough to melt this ice. Eventually all water life would die. With time, all water—except perhaps for a thin layer on the top during summer—would slowly turn to ice. The earth would be as frozen and desolate as the Arctic desert!

In fact, in a surprising number of ways, the properties of water seem to have been designed to make the world hospitable to life. Water has an unusually high capacity for storing heat. The seas and oceans act like great heat reservoirs—moderating hot summers and cold winters to make us more comfortable.

Try heating ice. It will melt into a small pool of water. The molecules in liquid water are close and they move about freely. They are still able to attract each other though they keep no shape of their own, and simply take on the shape of the container that holds them. Water remains a liquid between zero degree Celsius (its freezing point) and 100 degree Celsius (its boiling point). It is in liquid form at the temperatures found most commonly on the earth. This is again unusual, for no other substance remains liquid at these temperatures. If water were to behave like many of its close relatives, that is, substances having a similar structure, there would be no liquid water on the earth.



No shape!

Let us now heat water. As water gets hotter, its molecules gain energy and move faster and farther apart. As you heat it more, the molecules move so much that they eventually escape from the surface of the liquid, or evaporate.

Where has the water vanished? It has turned into an invisible state called water vapour! Its molecules have become much more restless. They move about very fast and keep bumping into each other. They are far apart and do not attract each other much. That is why a gas has no shape, and takes up more space than a liquid.

We can conclude that the form water takes depends on how tightly packed its molecules are and how fast they move. Also, that temperature affects the arrangement of water molecules.

The behaviour of water vapour is quite flexible. Water vapour can again change back into water if cooled. Take a look at the outside of a cold glass of water. It is moist. The water vapour in the air that comes into contact with the cold surface condenses into the tiny droplets of water that we see on the glass.

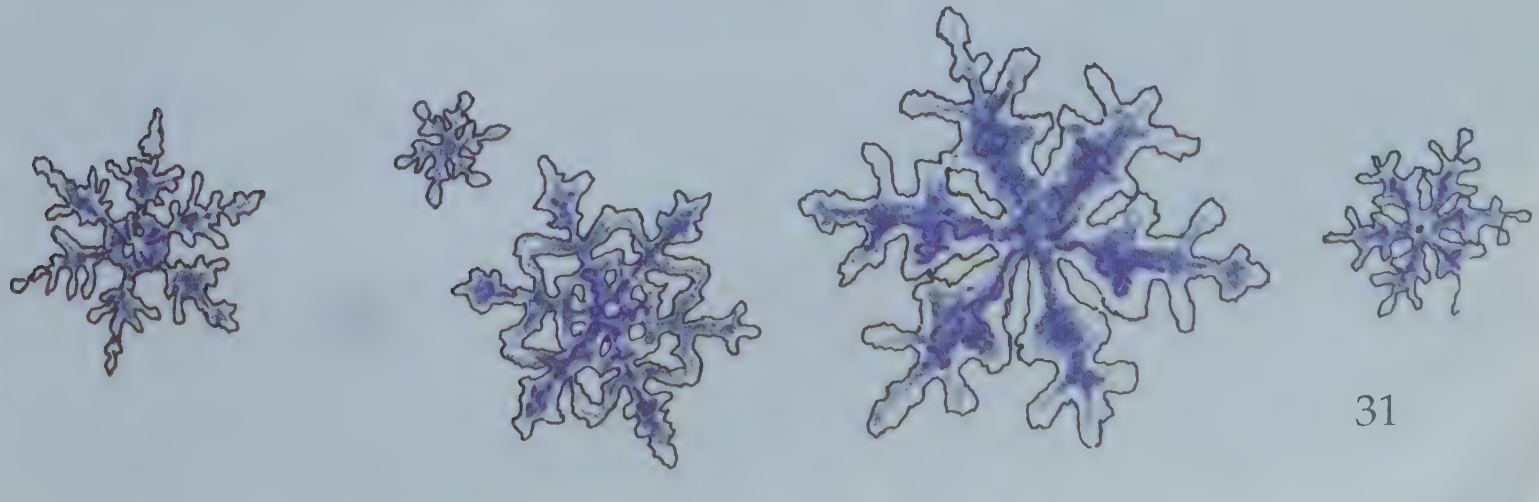
Water cycle

Something similar happens in nature on a very, very large scale. In nature's water cycle too, it is heat that makes water change its state. It might sound strange, but the sun makes it rain.

The hot sun blazes down on oceans, seas, lakes and rivers, evaporating some of their water. The water vapour spreads through the air. Warm air can hold much more water vapour than cold air. When warm air that is laden with water vapour cools, as for example by passing over some mountains into a colder air belt, some of it turns back into water. Little droplets of moisture form, just like on the outside of the cold glass, and these make clouds or fog or mist. If the clouds are chilled further, then the droplets join together to form bigger drops which are too heavy for the air to support. These fall as rain.

If you have been up in the hills in cold weather, you may have seen enough snow. You may have even made a snowman! Snow comes from cold, moist air too. Snowflakes form when water vapour turns into ice without first turning into liquid. Snowflakes are very tiny ice crystals, each having six sides. If you examine them under a magnifying glass, you will be able to see their delicate patterns.

The water cycle is like a giant wheel that never stops. It goes on everywhere. It has been estimated that every year a layer of water about four metres thick goes up in evaporation from the oceans, which form the world's water reservoirs. Water evaporates in giant quantities from land areas too—that is, from lakes, ponds, rivers, springs and wells. Fortunately, we do not lose this water but get it back in the form of rain and snow.

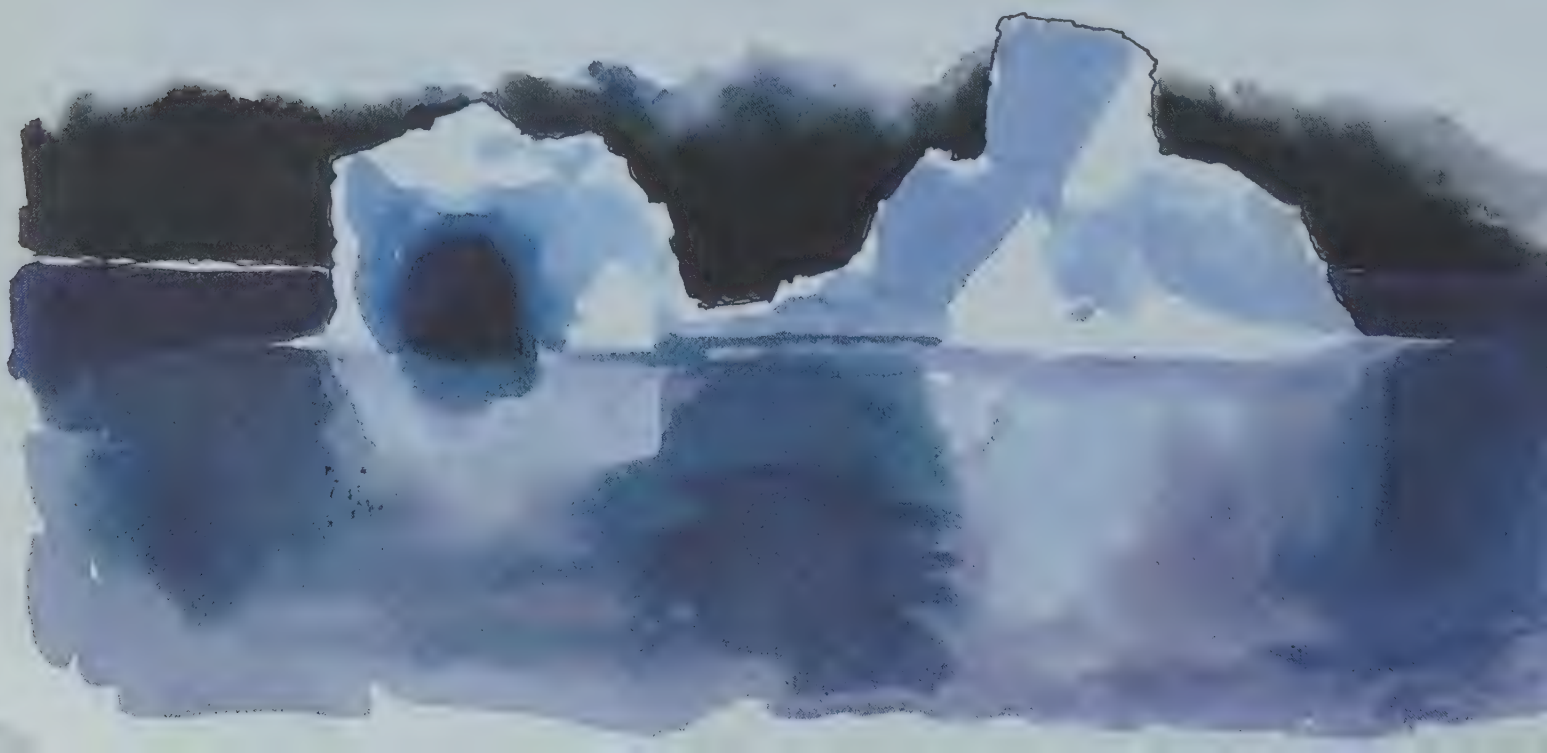


In fact, there is as much water on the earth today as there was before or will be in future. It does not increase or decrease. It is used and reused over and over again, yet never used up. Water only changes form or moves from place to place. And who knows? The water you drank with your lunch today may have flowed down the river Brahmaputra ten years before, or even been in an iceberg a century or two ago!

About 75 per cent of the earth's precipitation, that is, rain or snow, falls back directly on the oceans. Much of the rest evaporates quickly from puddles on the ground, rooftops, and so on. Some of this runs over land in the form of little streams. They meet and make bigger streams. The bigger streams join to form the rivers. They eventually flow into the sea or the ocean or lakes. The rest of this precipitation seeps into the earth to become an underground water supply. This forms underground rivers and returns to the sea. During dry periods the underground water supply keeps the rivers flowing.

'Locked up'

Only about three per cent of our earth's water is fresh water, and most of this is not easily available. Vast reserves of fresh water—over two per cent of the total water of the earth—remains virtually 'locked up' beyond our reach as ice in the Arctic and Antarctic regions.



Here snow accumulates in great layers. The bottom layers are pressed flat to form hard ice. This sometimes begins to move down slopes under the pressure of its own weight, helped by gravity. In flat areas, ice sheets spread out in all directions, but in mountainous regions these sheets move down as valley glaciers till they melt into rivers. Great and small chunks break off and float away as icebergs. Those reaching warmer waters eventually melt. A sudden and complete thaw of the ice will submerge all the land areas on the earth, except perhaps the highest mountain peaks. That is why environmentalists have expressed grave concern at the raised levels of carbon dioxide in the air causing the warming up of the earth (the greenhouse effect).

Groundwater makes up only 0.5 per cent of the earth's water whereas the rivers and lakes contain even less—merely a fiftieth of one per cent of the earth's water!

Ever since the world began, water has been shaping the earth as it moves through the giant water cycle. The rivers erode the land, carving valleys and building deltas as they empty into the sea. The waves pound against the coastlines, chiselling cliffs and cutting into or straightening the land. Glaciers cut down mighty mountains and plough valleys, changing the face of the rugged landscape. Water is responsible for most of the erosion, which may sometimes have a devastating effect on farmland. And when mighty rivers like the Brahmaputra flood, they spell disease and disaster for thousands as they wash away homes and livestock.

The Ganga transports about one million tonnes of sediment everyday! It has been estimated that at the present rate of erosion in the United States of America, all land will be worn down to sea level in a period of about 12 million years. The physical power of water can indeed be fearsome, for it can radically alter the face of the earth!

Human Needs

Fresh water is vital for the basic human needs like drinking, bathing, cooking, washing and irrigation of crops. Naturally, the earliest human settlements arose where fresh water was available.

On river banks

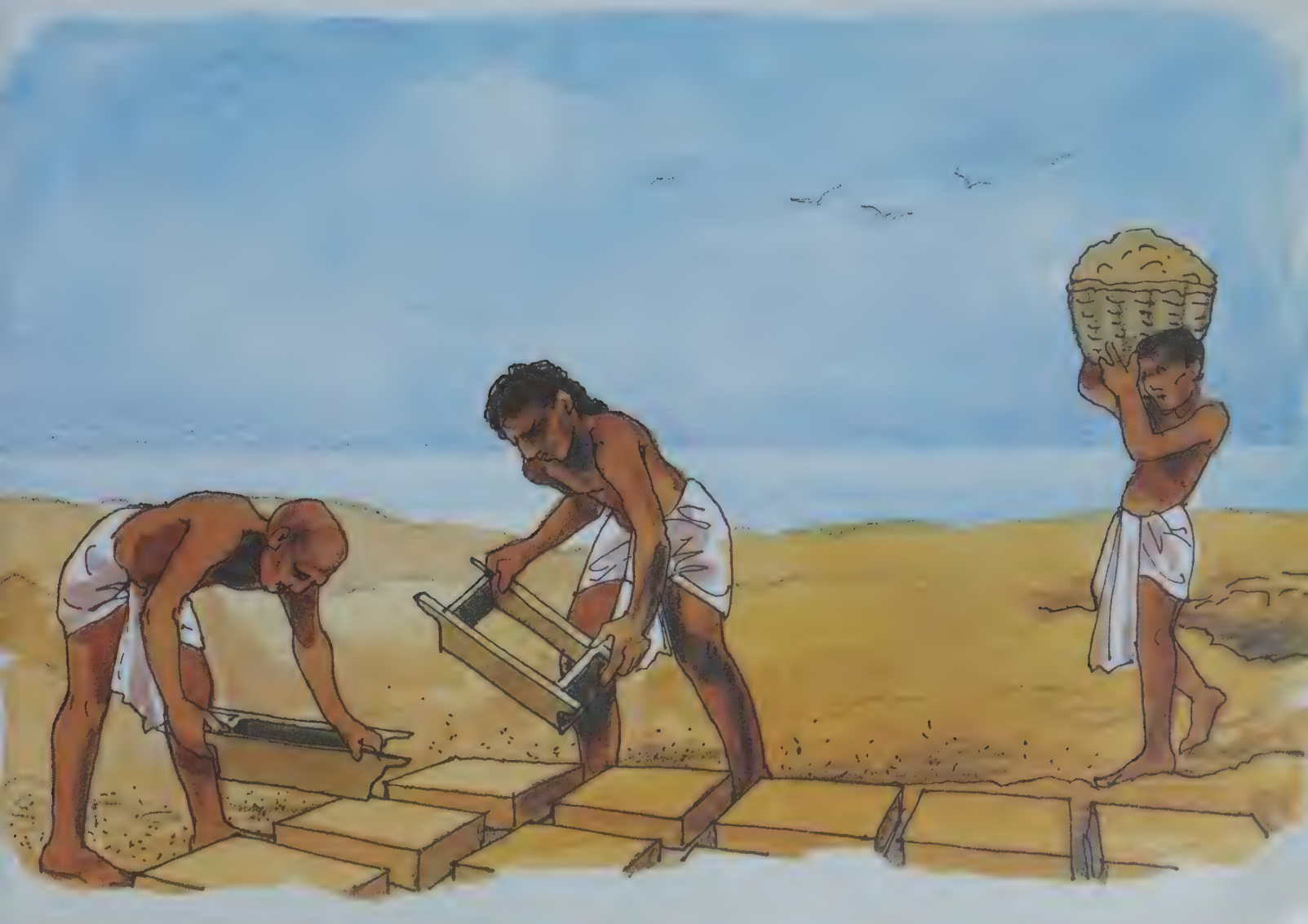
Primitive humans settled in their early homes to till the fertile land, helped by the animals they had domesticated. These homes were almost always near the rivers. In fact, the earliest civilizations began near the world's great rivers—the Tigris-Euphrates, the Indus, the Nile, the Hwang Ho. With water in plenty in these fertile regions and warm, sunny weather all the year round, crops flourished, providing food in plenty for man and beast alike. Wild fruits grew

in abundance. Man began using the clay from the river-bed to make bricks which, after hardening in the sun, were ideal for building houses. This is how settled communities began to flourish, independent of one another.

Rich harvests supported a healthier and denser population. They also allowed man time to think and to grow. He did not have to worry any longer about how to survive each day. In time, people were not necessarily all farmers but craftsmen, administrators, and so on. Occupational variation was an important step forward in civilization.

Many more things happened as people stayed in one place. They lived and worked together. They made ditches for irrigation along the river banks, so that the precious water could reach their crops even when there was no rain. New ways of using tools and making things they needed were discovered.

Communities were thus built. They huddled together for protection from outsiders and marauders, building their houses close with



boundaries around them. Eventually, self-contained villages, towns and cities came into existence. Large irrigation systems made the land productive and prosperous, and people lived peacefully under settled governments.

The river valleys became the first places in the world to support early civilizations which owed their wealth to water and soil of the fertile valleys. Many communities in Asia began along the coasts or rivers. Some of the names by which certain people are known today are reminders of their original water connections! For instance, Thailand's Chao Lei are literally 'people from the sea'. The Tagalogs of the Philippines means 'from the river'.

Civilizations

We are not really sure where exactly the earliest civilization started, but it is likely that this happened in the broad and fertile valley between the rivers Tigris and Euphrates which the Greeks called Mesopotamia, or 'the land between the two rivers'. It was here, in modern Iraq, that the *Bible* places the Garden of Eden, where it tells

us human life began. The early Sumerian inhabitants built clusters of huts, domesticated animals for milk, meat and skins to clothe themselves, and grew barley, wheat and other crops. The civilization developed into a sophisticated one, with flourishing cities, fine buildings, public water supply and drainage. The first known writing systems too were devised.

Despite everything, the farmer remained the backbone of the civilization, for it was his crops, grown in the rich silt, that fed the people. Floodwater was dammed in pools, natural and artificial. To water the crops through the dry season, gaps were made in the earthen walls and plugged again. Some of these ancient canals are marvels of engineering. It may sound unbelievable but one was 322 kilometres long and over 122 metres wide!

The ancient Greek historian, Herodotus, called Egypt the 'Gift of the Nile'. It is not difficult to understand why, for without this river, the longest in the world, the country would not have existed.

Close your eyes and try to imagine the arid wastelands of ancient Egypt 5,000 years ago. As the sun blazes down, wells dry up, the parched land cracks and the Nile is reduced to a small trickle. This is a rainless country without a cloud in the sky. The vast flat desert is fringed with limestone and sandstone mountains that are virtually uninhabitable. Suddenly, the life-giving waters of the Nile surge downwards through its valley, bringing new life and hope to its people. There is the promise of a good crop at last! Fish and wild birds teem in the river and the parched land bursts forth with grass and flowers.

According to its peasants, this yearly miracle of the Nile flooding has happened from time immemorial. It brings water and rich red soil to the desert from the mountains of Abyssinia. No wonder then that the river is held to be sacred. The early Egyptians believed the Nile to be the teardrops of a goddess! They worshipped Osiris as the God of the Nile.

The primitive Egyptians, who settled in the Nile valley, never more than 50 kilometres from its water's edge, learned to make huts, grow crops and domesticate animals. They led canals from the river to irrigate the farthest fields. They invented the *shadoof* (a pole with a bucket and counterpoise) to raise water to higher levels. Modern dams are built today but the *shadoofs* and canals are still being used. The civilization of ancient Egypt grew on this narrow strip of land, 1,200 kilometres long, on either side of the river and reached high peaks of achievement under the Pharaohs (rulers). The pyramids and the (inscrutable) Sphinx stand to this day as relics of a fascinating past.

Indus Valley

Closer home, the remains of another ancient civilization in the Indus Valley of the Indian subcontinent reveal its astonishing development. Nearly 5,000 years ago the people of Mohenjo-daro in Sind and Harappa in Punjab had built well-planned cities in brick, complete with drainage systems. A citadel, a granary and even a large public bath have been unearthed from the sites. The inhabitants were skilled potters; stone tools, copper and bronze knives and weapons, and ornamental figures have been discovered among the ruins of this remarkable civilization. Archaeologists have also discovered many thousand seals with pictorial writing. Once they decipher these, they may perhaps find the answers to many unsolved questions.

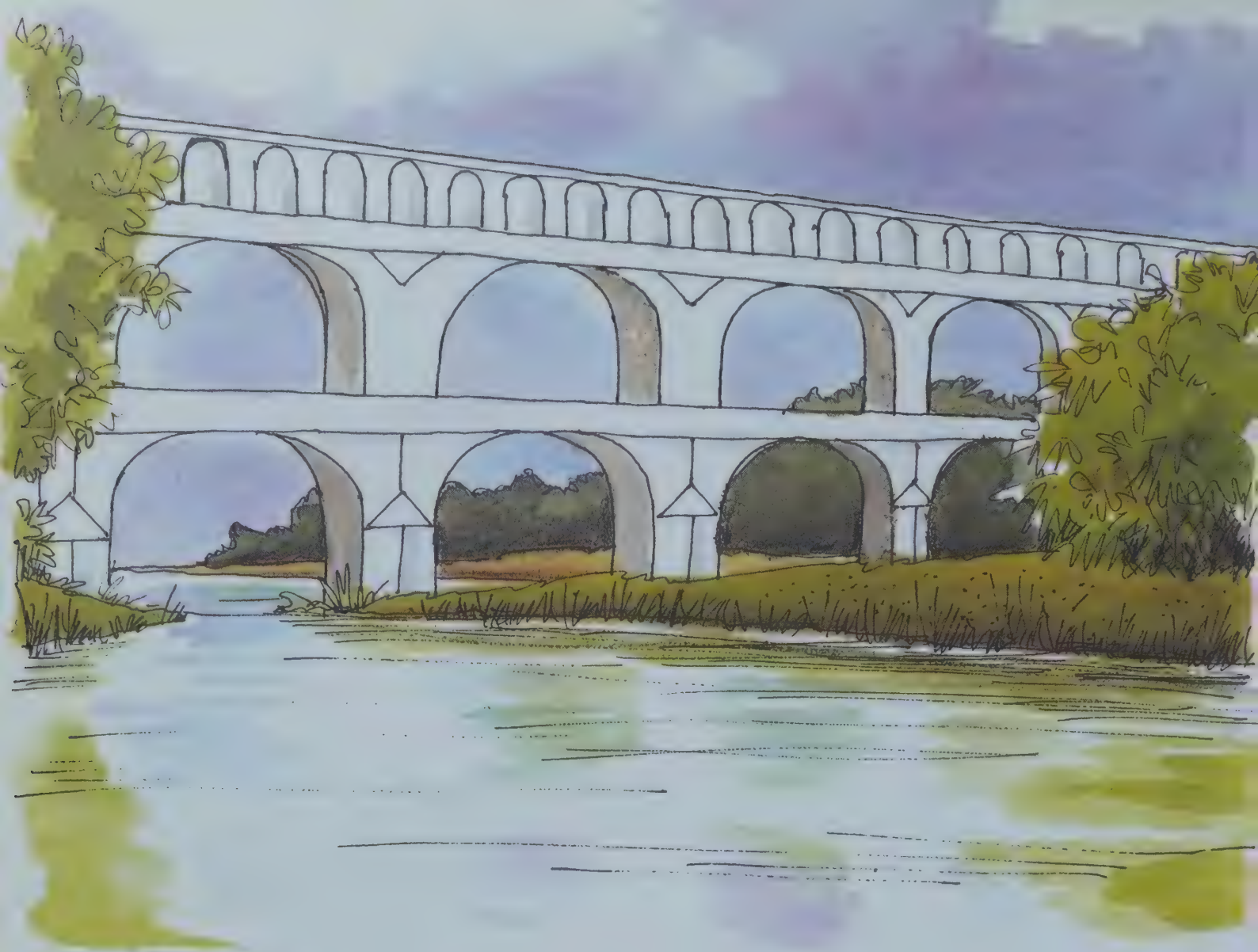
As in Mesopotamia, it was irrigated, organized agriculture that supported the Indus Valley people. They were skilled in cultivating the spacious and fertile Indus river valley while controlling its devastating annual flood. They grew wheat and barley in plenty; peas, mustard, sesame, and a few date stones have also been found, along with some of the earliest traces of cotton known. The people seem to have been animal lovers. Dogs, cats, cattle and fowl were domesticated, and possibly pigs, camels, buffaloes and even elephants! Ivory was popularly used. Trade is believed to have existed between these people and those of West Asia.

The initial understanding of this civilization had to be revised radically as a result of the assiduous researches conducted by archaeologists and specialists. This unique civilization spread extensively all over the Indian subcontinent and traces have been found in more than a hundred towns and villages. Ultimately, the floods that fertilized the valley probably brought about in stages its final destruction.

Similar things were happening in a major river valley in the Far East. A considerably ancient civilization arose in China's Hwang Ho river valley when several Stone Age villages were built along its banks. This civilization spread south, west and east from this region. The Shang people lived by hunting, fishing and farming. They established silk, pottery and metal industries, and were considered to be unsurpassed in their craftsmanship.

Through five centuries, eleven aqueducts brought water to Rome from as far away as 92 kilometres! Mostly, these were underground pipes made of stone and terracotta—but they were sometimes made of wood, leather, lead and bronze. Some crossed over valleys on stone arches. Ancient Romans constructed aqueducts, canals and water reservoirs all over their empire and the coast of North Africa. After they left, their water projects were abandoned. Many of these places are dry deserts today.

Interestingly, it was when water supplies failed or were poorly managed that the early civilizations usually crumbled. Historians believe that the Mesopotamian civilization fell because of poor irrigation in later times which caused their crops to fail and agriculture to collapse.



Marine Life

Water gives us something else of much importance—seafood! Rivers, seas and oceans are the home of about 14,000 kinds of fishes and other marine animals, and provide a stable environment for marine life. Since sunlight can penetrate but a few hundred metres into the sea, marine life exists mostly near the surface. Plants too cannot live at great depths as they need sunlight to produce food.

Over the centuries, fishermen have caught fish from freshwater lakes, ponds and rivers, even rice fields and swamps, using nets, lines, hooks and traps. This rich marine life supplemented food on land, especially where meat was not commonly eaten.

Early man made simple fishing boats and rafts from logs of wood to help him fish in the open seas too. He was sometimes brave enough to drift with the currents to distant islands. In course of time, these boats began to be used as means of transport.

Long before the days of rail and road travel, people went from one place to another by rivers and seas. Later, boats with oars and sailing vessels became bigger and faster. These carried goods, and more, traditions and beliefs. This often brought scattered communities together under one political and cultural unit.

The Indian peninsula, with her long coastline, was one of the earliest seafaring nations. Her sailors went far and near, carrying many varieties of exotic silks and spices, along with our rich culture and values. The latter made a commerce in ideas. Its unique character was the absence of any instance of territorial incursion. Water shaped human life and thought as it was our earliest means of communication.

The call of the blue sea has been irresistible to man, often spurring on the spirit of adventure and exploration. Down the ages, many men who were too restless to settle down to the humdrum life of the early farmer chose to sail on the seas. They sailed in search of new lands and uncharted trade routes, sometimes making important geographical discoveries. They went in search of rare minerals and gems too which were valuable and believed to have magical properties. Fortunes were sought and lost in the dark depths, and many an ancient mariner did not live to tell his tale. But the call of the sea endured! A great many old and wonderful legends began this way.

The Phoenicians were probably the greatest seafarers of the ancient world, coming from the Mediterranean coastlands of what are now Syria, Lebanon and Israel. Between 1200 B.C. and 800 B.C. these hardy mariners had sailed over the Mediterranean, as far as the Atlantic and west coast of Africa, founding many trading stations and colonies.

Source of energy

As man made new discoveries, he learned to put the energy of water to great use. For hundreds and thousands of years his main source of energy had been the food that enabled his muscles to do

his work. Early man used this energy in his struggle to live and gain mastery over animals and nature. Later, he learned that other forms of energy could also be used. He began to use the energy of the wind and running water to carry him and his goods on rafts downstream. He had discovered water power, which comes from the energy in flowing or falling water.

The water wheel, about 2,000 years old, was perhaps the earliest mechanical device to ease the work of humans and animals. This was a wheel with a paddle around its rim. When moving water hit the paddles, it made the wheel turn. This turning wheel could drive a machine for heavy tasks like raising water or grinding grain.

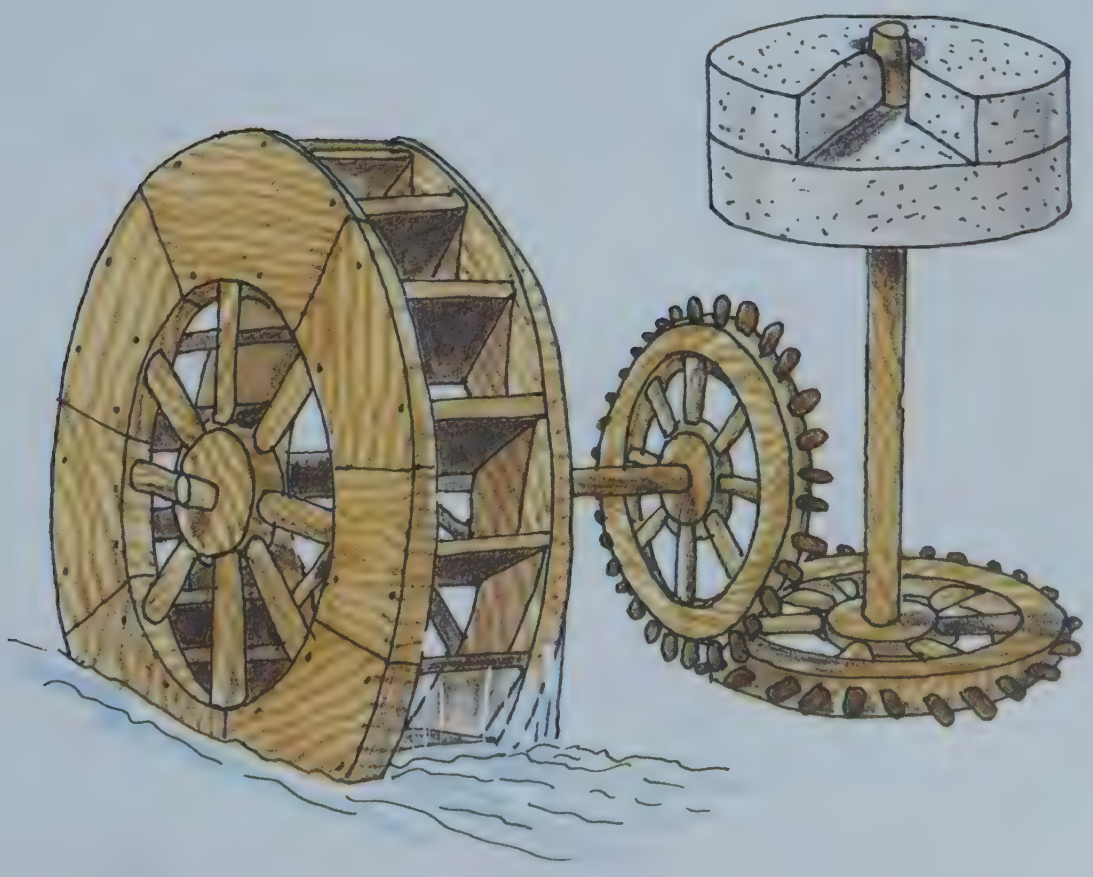
The ancient Greeks had discovered the amazing energy of water. They knew that on heating water, steam was produced which took up more space than the original quantity of water. When water was heated in a closed container, the expanding steam would push most forcefully against its walls, looking for an outlet to whistle through. The energy of the escaping steam could be put to work. Strangely, the Greeks hardly built any devices that made good use of steam. This needed clever engineering.

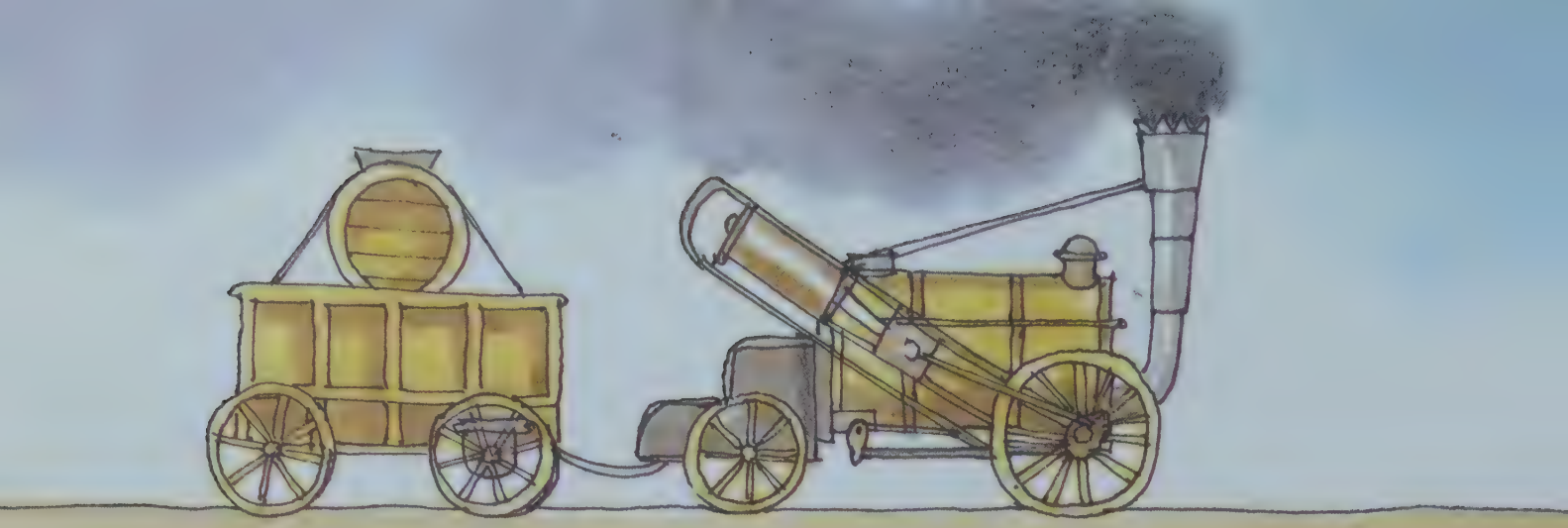
One might say that modern progress began in 1690 when Denis Papin made a study of water vapour. His 'steam digester', a boiler, was the forerunner of all steam engines later used to convert the force of vapourized water into movement.

The man who made the biggest advance in the engine's design was James Watt who brought out his steam engine in the eighteenth century. From then onwards steam energy was put to hard tasks.

Industrial revolution

When coal is burnt, its heat turns water into steam. If this steam is trapped as it expands, it can be made to pull and push rods in order to turn a wheel that runs a pump. These 'steam engines' can be made to run many other things as well, like machines in factories.





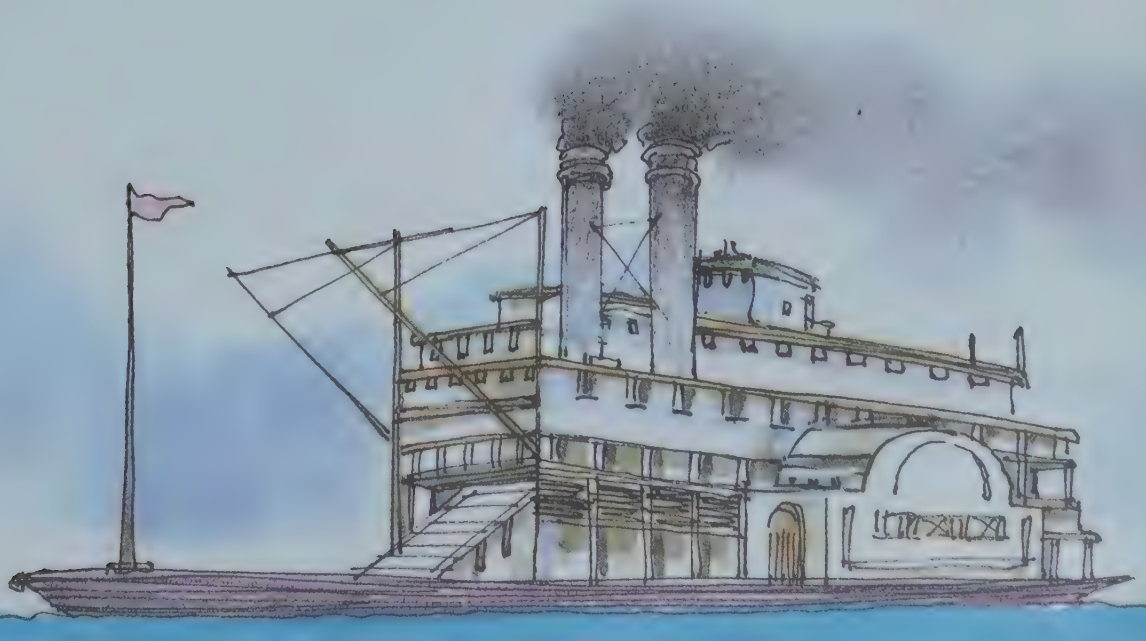
This ingenious discovery brought in the Industrial Revolution in the West. Machines began to replace manpower. This meant faster production and saving of time and labour. Many things changed! There was more time at hand to study science and to invent. Technology began to make the most rapid strides. The nineteenth century came to be known also as the Steam Age.

The power obtained by heating water was so great that transport on sea and land was soon driven by special steam-boilers. These could turn huge paddles to propel ships forward. By the early nineteenth century steam engines were moving ships on charted paths across the seas, against the direction of winds and currents. On land they

moved locomotives over rails without the use of horses. People could travel between cities on railway lines. For some, the black steam locomotive was the work of the devil, but it was moving people and goods faster than ever before. Transport had been revolutionized!

The steam engine changed the world. Countries could buy and sell goods rapidly through steamship and steam locomotive. If there was food shortage in one place, food could now be quickly brought in. The first steam warships were also built and these soon replaced sailing ships.

Man had thus learned to use water in so many different ways in his life. However, this was but the beginning...



Today

How you grumble and groan when the water supply goes off in the middle of your shower! There is every chance that you may miss the school bus. There is not even a well nearby to draw water from if you have not stored away a bucketful! In cities we rely on the waterworks for a supply of water. The government locates suitable sources before purifying and distributing it through pipelines.

Human dependence on water has increased in our times. Modern industrial civilization is built entirely upon the generation of power. It depends no less on water than did those first civilizations that grew in the river valleys.

More than ever, we depend on water for irrigation, fishing and transportation. Rivers are harnessed for energy and seabeds are tapped for oils and minerals. Water is also used in most industries, in science and in medicine. Modern man needs water for all his domestic needs as much as his ancestors did.

Multi-purpose benefits

Irrigation: We saw that water covers three-fourths of our earth, but many places are still short of water. That is why your tap may sometimes run dry. Some deserts, like Ambu's, get little or no water at all, so life becomes difficult there. Irrigation is invaluable today in making the land productive. Large-scale irrigation not only extends the area under cultivation but raises crop yield.

Irrigation is still the mainstay of agricultural economies like India. The availability of water varies from place to place and time to time. Ours is a monsoon country, and most of the rain falls in only three or four months a year. Water scarcity is common the rest of the year. The early farmers were entirely at the mercy of rain and river supplies. They prayed to the rain gods for fear of drought.

In modern irrigation projects, dams are constructed across rivers to regulate the water supply. The water is distributed to the fields, often at a considerable distance, through a network of canals and ditches. In this way crops can be protected from the severely damaging effects of both floods and drought.

Indian independence saw the birth of many ambitious projects. Multi-purpose projects like the Bhakra Nangal Project and the Damodar Valley Project have utilized river water to the fullest in times of drought and floods. The Bhakra Dam on the river Satluj irrigates an area of 1.4 million hectares in Himachal Pradesh, Punjab, Haryana, Rajasthan and Delhi. It has brought new hope and life to these regions.

River Damodar was once called the 'River of Sorrow' because of the havoc its floods wreaked in West Bengal. The Damodar Valley Project on this river now enables a regular water supply for irrigation, domestic needs, industry and generation of hydroelectric power. Such projects have also helped prevent soil erosion by floods, and have helped preserve wildlife, perhaps our most precious heritage.

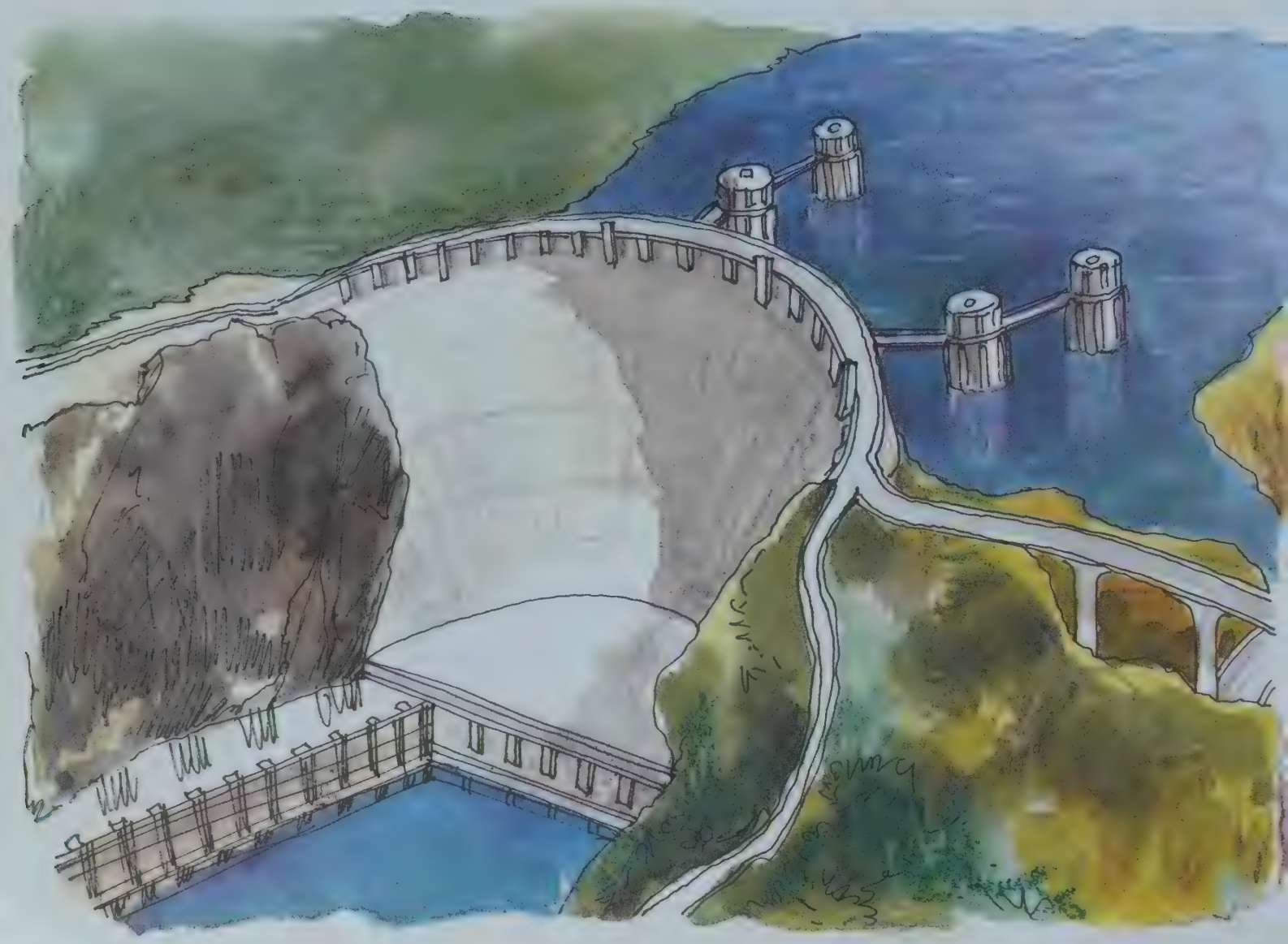
Groundwater: Man has been tapping underground water through wells, or collecting rainwater in natural hollows or tanks. Earlier, human labour and animals were used for drawing water. It was a slow and laborious process. Now, with electrification of most rural areas, pumps are widely used for drawing water from tubewells and open wells.

However, the days when rural folk in India had to walk several kilometres for water for their domestic needs, an earthen pitcher balanced on their heads or their sides, are still not over. In most parts of our county, water supplies are inadequate and irregular, although we have been able to bring almost a fifth of our total cultivated area under irrigation.

In India, unfortunately, political factors such as boundaries between the States and even neighbouring countries, like Pakistan and Bangladesh, stand in the way of sharing available river waters.

Electricity: Electricity, the most useful form of energy to run machines, is usually produced by a generator which is driven by turbines. These work rather like the ancient water wheel. Traditionally, steam produced by burning coal, oil or natural gas drove the turbines. Nowadays dam sites on fast-flowing rivers, and even waterfalls, are commonly used to generate electricity, using the water pressure to drive a turbine.

Usually a hydroelectric power station is built beside a river. A dam is constructed to hold back the river water and then to feed it with great strength to the turbines. This water power or hydroelectricity is cheaper than thermal or diesel power and helps meet the growing energy needs of cities and industries in many regions.



Oil and gas: The ocean is a vast treasure house from which we get many important and unexpected things. Locked up in its waters is a great store of salts and minerals in solution. Oxygen, carbon dioxide and nitrogen from the atmosphere are also found dissolved in sea water. Sea water is an important commercial source of common salt, gravel, magnesium, copper, cobalt, bromine and many other substances in wide industrial use.

If you travel by train to Mumbai, you will on the way see heaps of salt obtained from drying sea water. The sea water fills shallow pools. The water turns into vapour under the intense heat of sunrays leaving the salt behind.

There is something else that comes from the ocean floor, and which plays a primary role in life today—petroleum. It is one of our most vital sources of energy. It gives us petrol, diesel oil, kerosene and thousands of other products and really keeps the world moving! It is essential for all industrialization programmes and is a major foreign exchange earner.

Petroleum and natural gas are found deep below the ocean floor. They are both formed from the remains of tiny plants and animals which lived millions of years ago in the sea. When they died, they sank to the bottom and gradually their bodies were covered with sediment. Over millions of years their remains decomposed into gas and oil which were trapped in pockets in the rocks, far below the ocean floor. To reach this we have to drill right down through the layers of rock to these pockets.

Drilling rigs are towed by ships to an oil exploration site. Of course, they must be strong enough to withstand the fierce storms at sea. Some rigs are supported by floats. Wells are carefully drilled and the oil is brought out through pipes. At first oil wells were dug only in shallow waters near the coast. Gradually they were built farther away from land, out in the open sea. They have been drilled in great number in oil-rich places like the Persian Gulf, the Caribbean Sea, the Adriatic Sea, the Caspian Sea and the North Sea.

In India, major oil reserves were found deep under the seabed off

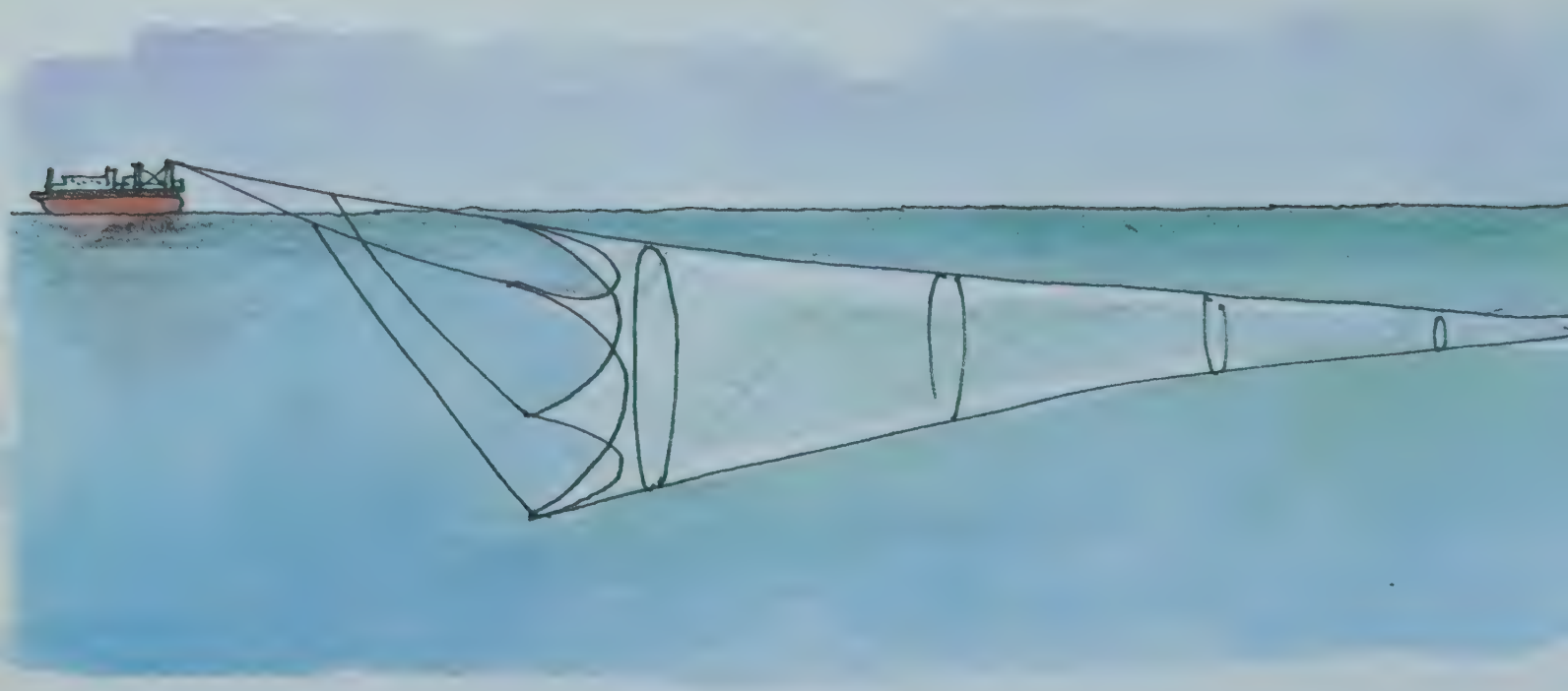
the Bombay coast, 115 kilometres from the shore. So far this oilfield, known as Bombay High, has been the richest discovered in India. The SAGAR SAMRAT, bought from Japan, was the first mobile offshore drilling platform. Now India too manufactures oil drills and mobile platforms for drilling in deep coastal waters. The latest oil deposit discoveries have also come from offshore areas—off the deltaic coasts of the Godavari, Krishna, Kaveri and Mahanadi.

Natural gas and petroleum go hand in hand, for gas reserves are generally found in association with oilfields—as in the offshore oilfields of Gujarat, Maharashtra, Tamil Nadu, Andhra Pradesh and Orissa. Natural gas is used for cooking and heating.

Food: The sea continues to provide us with tasty seafood. In Bengal, fish is an indispensable part of the daily meal. In much of Asia, rice eaten with fish is a staple diet. The warm and shallow waters team with marine life and villagers catch freshwater fish in rice fields, rivers and swamps. It is as though time has stood still. They use lines, hooks and nets as they did in earlier days. Bigger yields are obtained from fish, prawns, and oysters reared in captivity in reservoirs, partially cleared swamps and artificial ponds. In China, fish culture is undertaken in paddy fields. If you visit Japan, you could see an oyster farm where oysters are reared to produce valuable pearls.

Fishing remains a major modern occupation all over the world. Fishing boats used by small fishermen in coastal waters are propelled by oars, sails or motors. Longer voyages for deep sea commercial fishing are carried out in powered boats using modern fishing techniques. These result in very big catches. The boats have facilities for processing and preserving the fish caught over a number of days since fish do not stay fresh for long.

Technology has revolutionized the fishing rod and line. Modern fishing boats can use sonar signals to find the position of shoals of fish. Some boats catch fish by sucking them up. They use lights too to attract fish. They are then pumped up and the water is drained away. However, most fish are caught by huge nets (trawls) pulled



through the water behind the boat or trawler. The net is like a tube—the bottom end is kept open with weights, the top edge is lined with floats. When it is full, it is hauled on board by a machine.

Man takes about 76 million tonnes of fish from the sea each year. About half of this belongs to the herring family, the world's most important commercial species. The greatest fishing grounds are in the colder regions where there is an abundance of plankton, and fish thrive there in the greatest numbers. There are some important coastal fisheries in tropical regions as well.

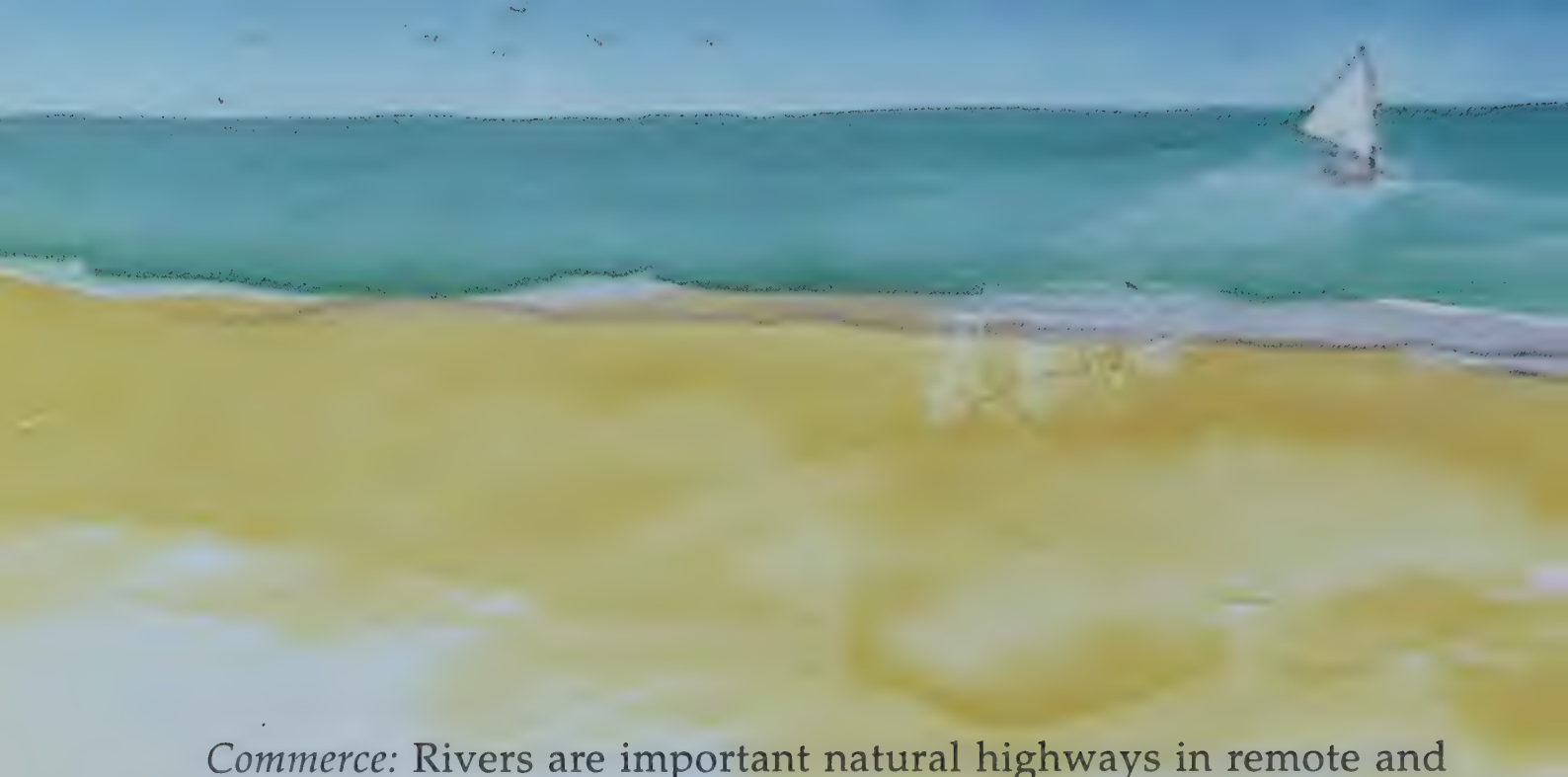
There is a thriving worldwide trade in salted, canned, dried and frozen fish and fish products. The oil derived from fish is used as a tonic and their residuals as fertilizers.

Transport: We have come a long way in communication and transport since the early days of water transport when boats and small sailing ships relied completely on currents and the wind to drive them along. Today, huge ships are built of iron and powered by steam turbines or diesel engines. They can be over 370 metres long. Nuclear power is used for some warships. These include destroyers and frigates which carry missiles, aircraft carriers which can carry up to 100 fighter planes and submarines. They often carry deadly nuclear missiles.

Ships are exciting in that they bring with them a whiff of the world's great oceans as they sail to distant lands often through stormy waters. There are container ships, bulk carriers, general cargo ships, tankers, roll-on/roll-off vessels, and luxurious passenger liners. They carry their heavy cargoes of food, coal, machines, timber, and people! Passenger liners are like huge floating hotels on the high seas. They are mainly used for holiday cruises. Ferries carry passengers at regular hours over shorter distances.

Major ports all over the world handle international sea-borne trade. India has about twelve major ports to handle her foreign trade, most of which takes place by the sea.

Sometimes canals are dug to join two rivers or bodies of water. The oldest is the Grand Canal in China. The greatest and most famous are the Panama Canal joining the Pacific and Atlantic Oceans, and the Suez Canal joining the Mediterranean and the Red Seas. These man-made canals have cut down distances for ships that once had to sail around the great continents of South America and Africa.



Commerce: Rivers are important natural highways in remote and sparsely populated areas. Inland, rivers are commonly used for transporting bulk cargo and are invaluable commercial waterways hundreds of miles from the sea. The Mississippi river navigable for over 1,100 kilometres has been used as a water highway since the days of early explorers. The Amazon, Nile, Yangtze, Ganga, and other large rivers of the world are important for transportation. And even today, in densely wooded countries, lumberjacks use the river currents to carry heavy logs of wood to the sawmill or port.

In much of Asia, which is abundantly endowed with rivers and lakes, barges and boats are laden with cargo and there is a heavy traffic of fast passenger boats. There are floating markets of sampans which sell supplies and even cooked food to water-front houses. The waters of this region swarm with native crafts like the 'bugis' boats of Indonesia and the proa or 'prahu' of Malayasia.

What a treat a holiday by the sea is! The call of the water is always difficult to resist—tourist spots by the sea, lakes and rivers are great favourites. Swimming, sailing, scuba-diving, water-skiing, water parachuting and windsurfing are some popular water sports that draw the adventurous to the seaside. Many holidaymakers are content with collecting sea shells and building sandcastles on the beach. The thrill of deep-sea diving and underwater photography can be fascinating too. For, under water lies a wonderful world of marine plant and animal life, just waiting to be explored!

Vast Potential

The seas are the last frontier on planet Earth to explore and to conquer. Little had we realized their vast economic potential. The earth is fast exhausting her natural resources, while a population and industrial explosion means a growing need for food, water, minerals and power. Suddenly we are awakening to what lies below the waves. For here exists a vast, virgin territory with economic rewards. Our very survival as a race may depend on this.

It is believed that we can get most of what we need from the oceans—food, water, power, and chemicals, enough to make us self-sufficient.

Sea farming

Old habits certainly die hard. We have become used to eating the same kind of food all the time. How about trying to change some of our eating habits? We could certainly get all the food our bodies need! As we saw, fishing fleets today take in huge shoals of popular varieties of fish like herring, mackerel, cod and sardines. Many of these species are now in decline. Sometimes so many fish are caught in some areas that very few remain for the following year. Overfishing of the young ones especially prevents their breeding.

There exist 14,000 kinds of fish in the oceans. One could not ask for more variety! If we caught and ate lots of different kinds of sea animals and plants, we could get far more food from the oceans. This could well be the answer to our food shortages.

So far, the seas of the far north have been fished most intensely but little commercial fishing has been carried out in the Antarctic.

The oceans of the far south certainly hold some of the richest untapped food reserves in the world.

It is probable that in the future, instead of hunting fish we may have to farm the seas—rather like the early nomadic hunter who settled down to breeding and rearing animals on land. It has even been suggested that dolphins could be trained, rather like sheepdogs, to herd the fish together!

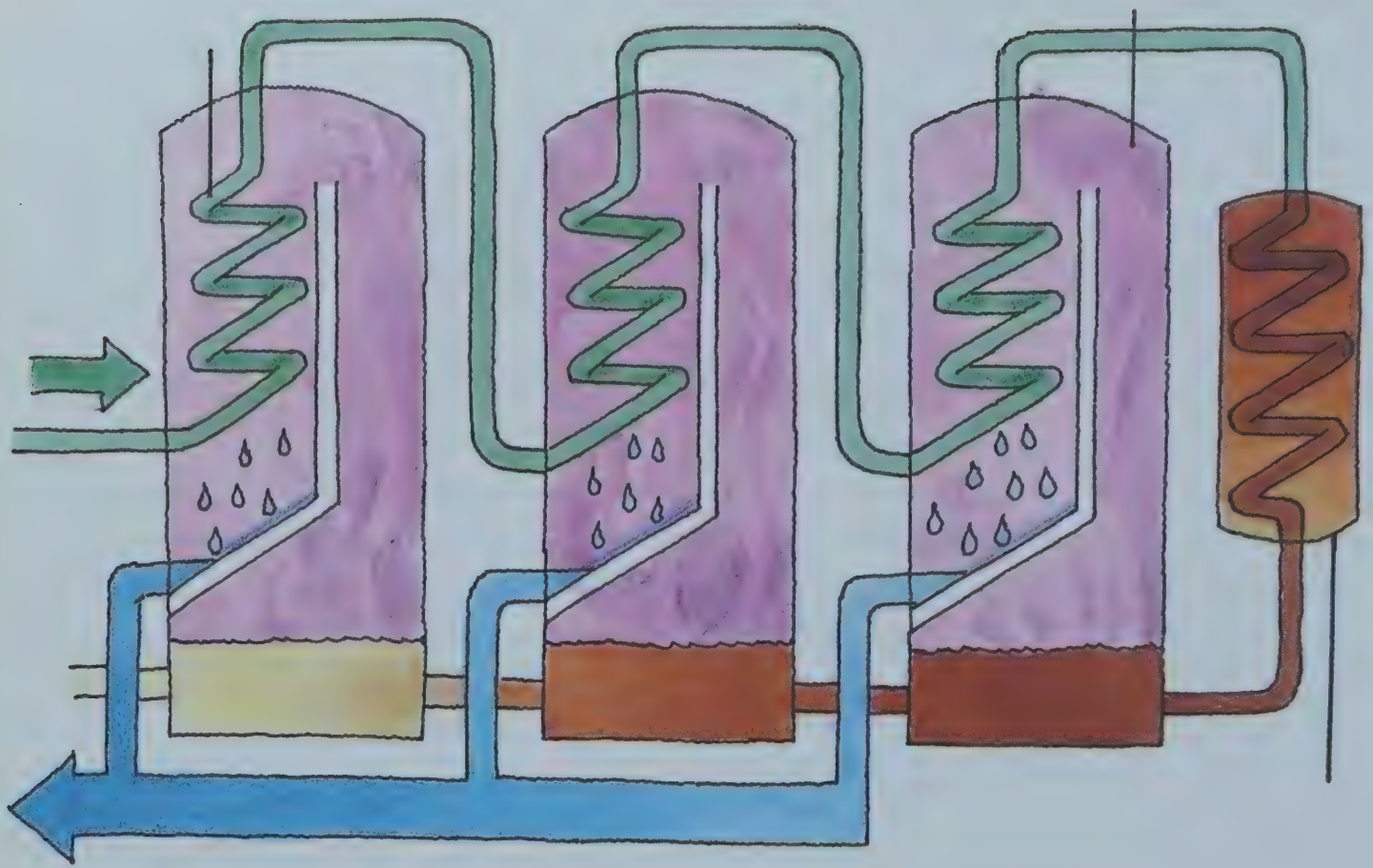
Our future world could use water for many novel projects. Scientists have been experimenting with soil-less culture or 'hydroponics', the cultivation of plants in nutrient-enriched water with or without the mechanical support of sand or gravel. Once installed, this process could be used in places where watering and fertilizing of crops by labour is difficult. Hydroponics has been shown to yield high production in a wide variety of vegetables and crops.

Desalination

"Water, water, everywhere, but not a drop to drink..."

About 97 per cent of the earth's water lies in the oceans. Throughout history, when people needed water, they looked longingly at this endless supply. However, we cannot drink sea water—it eventually causes death by dehydration as the body cells try to get rid of the excess salt from the water. Nor can people use sea water for agriculture, for it kills most crops; nor in industry where it quickly rusts most machinery. However, as we need more and more water today, there is a pressing need to purify sea water.

Already, in some places where fresh water is in acute short supply, scientists have built plants for making sea water fit for consumption as well as for industrial purposes by removing the salt. The largest number of desalting plants are in the Middle East. Earlier, water had to be brought by pipeline over long distances in desert countries like Kuwait. Here all the fresh water used today is obtained by desalination of sea water.



The desalination (salt removal) processes used most commonly today are distillation, reverse osmosis and electro-dialysis. However, all these methods are expensive. Once the cost of desalination of water decreases, more and more places may begin using such water. It is likely that man will be compelled to turn to the sea on a large scale in the future.

The idea of towing huge icebergs from the Arctic and Antarctic oceans to ease water shortages in hot desert areas may seem a fantastic one—for, as you may well ask, will these not melt before they reach their destination? Yet the future might find ways and means to do this, for these salt-free icebergs are good drinking water sources.

Tidal Power

We need energy to run machines, and we will need lots more of it in the future. Our natural sources such as oil and gas will eventually run out, so the search is on for new forms of energy in the future. The power of rivers is already being exploited for hydroelectricity. In India, the upper reaches of rivers rising in the Himalayas flow down swiftly, forming cascades and waterfalls. They are useful future sites for locating hydroelectric power stations.

The sea is a vast storehouse of energy. Its power is non-polluting, and it will never run out. If you have been to the seaside, you must have watched the immense power of the waves as they come and go, and break on the seashore. They are mighty enough to carve out cliffs and breach sea walls. They can even sink ships. Engineers are already trying to design machines to turn this up and down motion of the waves into electricity.

You will also have noticed at the seaside how high tide and low tide levels vary everyday. The difference in some places is as much as 12 metres! In early times, sailors waited for high tide to lift their ships and carry them out to sea. They were making use of the enormous tidal energy.

The constant force of the tides is already being used to produce electric power. The first tidal power plant opened in 1966 near St. Malo on the estuary of the river Rance in France. An estuary is the deep broad area where the river flows into the sea. It contains a mixture of fresh water from the river and salt water from the ocean. The level of estuary water rises and falls with the tides of the sea. Estuary dams can generate electricity by harnessing these tidal changes to turn turbines which drive generators.

The movement of high and low tides is clearly a great source of unused energy. Harnessed on a big scale, the power generated could be enormous. This would be more reliable than other sources of hydroelectricity, as the regular rise and fall of the tide is unaffected by adverse weather conditions.

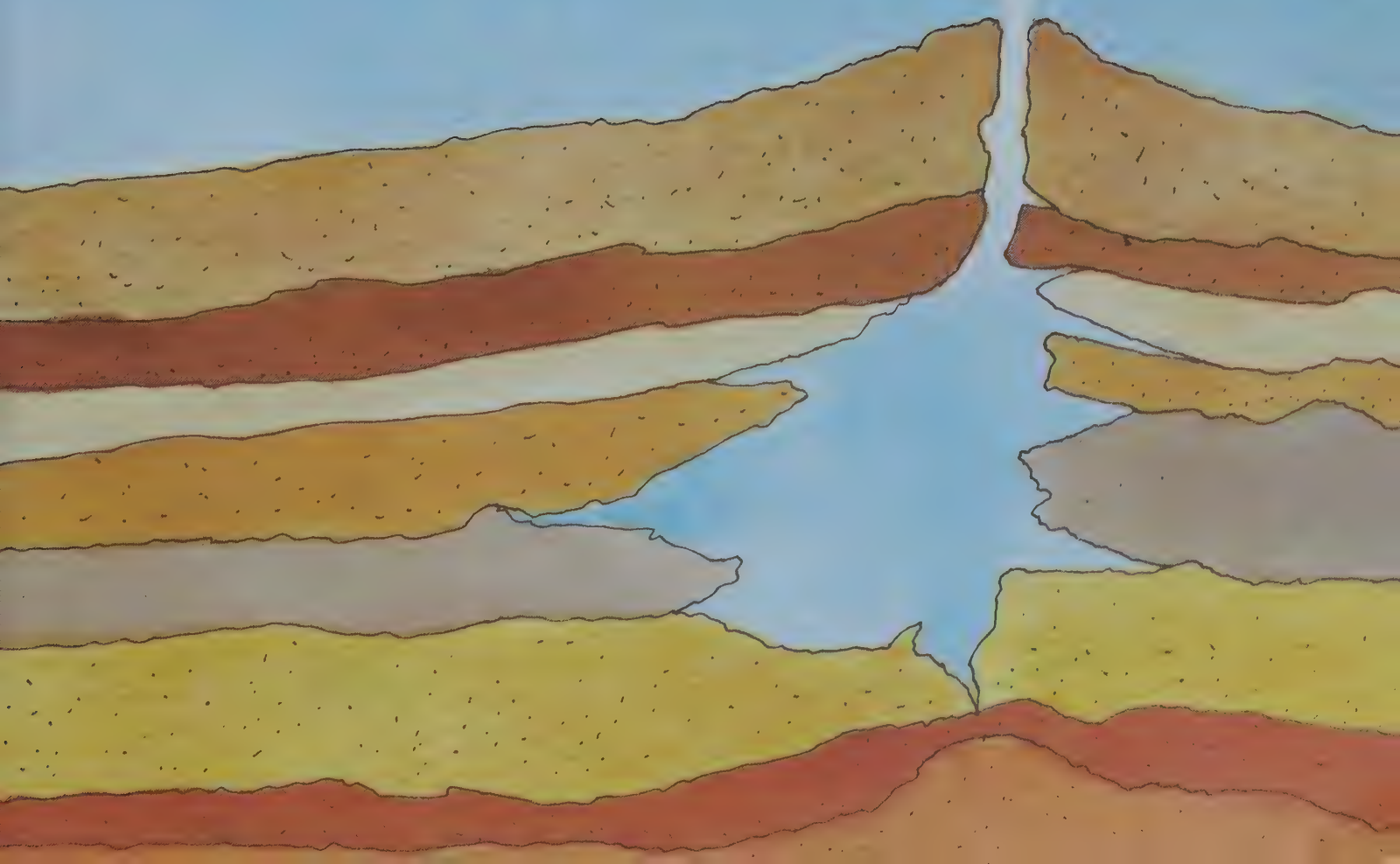
Geothermal energy

An enormous amount of energy lies beneath the surface of the earth as well. This is called geothermal energy. The layers of rock deep in the earth's crust are very hot and temperatures increase towards the centre of the earth where it is believed to be over 5,000 degree Celsius.

Geysers are a well-known result of geothermal energy. These are large spouts, found mainly in New Zealand, the United States of America and Iceland, through which steam and hot water force their way up through cracks in the earth's surface. They come from huge underground lakes of boiling water which lie deep beneath the land surface, usually in areas of volcanic activity. They are already used widely in Iceland's capital city, Reykjavik, to heat homes and offices. In the future even artificial geysers could be used as a valuable energy

source. Wells could be drilled deep down to an underground geothermal reservoir located by geologists. As the steam from the underground boiling water rushes to the surface, it could spin a turbine connected to an electricity generator.

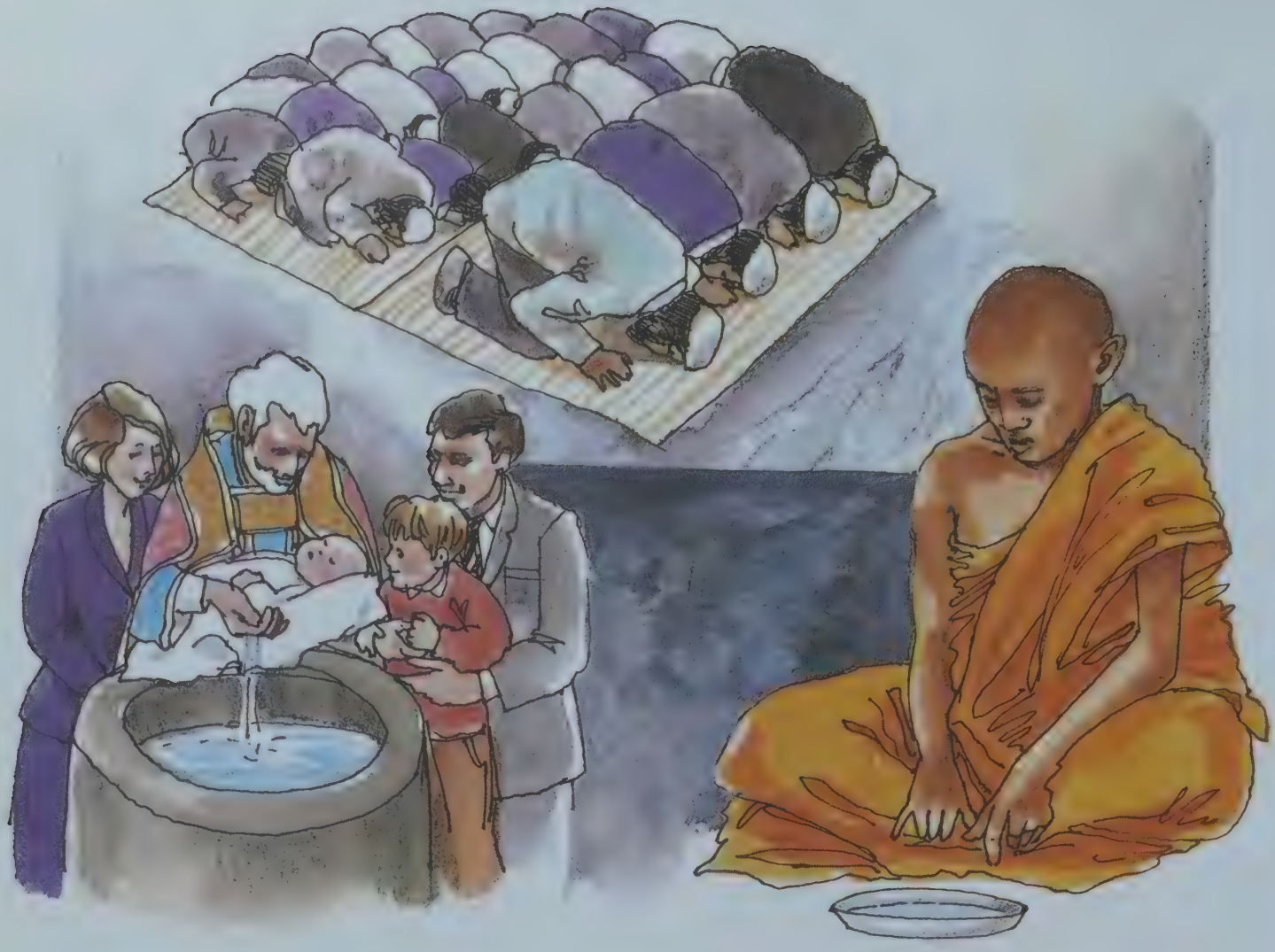
Of course, we have yet to exploit fully the petroleum and natural gas reserves under the sea. In India, the continental shelf and the area around the Andaman and Nicobar Islands are believed to harbour many such valuable deposits.



Underwater colonies?

Science fiction dreams of humans living in space colonies when the earth's resources finally run out and it becomes too polluted to live in. Could we save ourselves from doom by settling down nearer home? It seems too fantastic to be possible—but one day we may build dome-cities right here in our 'Planet Ocean'! We would have everything we need here—power from the ocean currents to generate light and heat, oxygen from marine plants, and fish farms in great cages outside the dome, rather like farmlands. Hydrojets could be used as transport between the different dome-cities that dot the seabed. And, of course, there could be land link tunnels for the curious who would like a feel of solid ground!

Dreams sometimes become reality. Who knows what the future holds as we explore the potential of the world's great storehouse of treasures! Time is running out as mankind depletes the earth's once bountiful reserves fast. Will the great life-giving waters come to our rescue as we edge towards catastrophe?



Water Lore

A Christian priest sprinkles holy water on the forehead of a baby to baptize it or receive it into the faith.

All Muslims must wash or touch water to different parts of their body that is, the face, hands, feet and top of the head, before saying their prayers.

Ritual immersion of the body in water has always played an important part in Judaism as a symbol of purification.

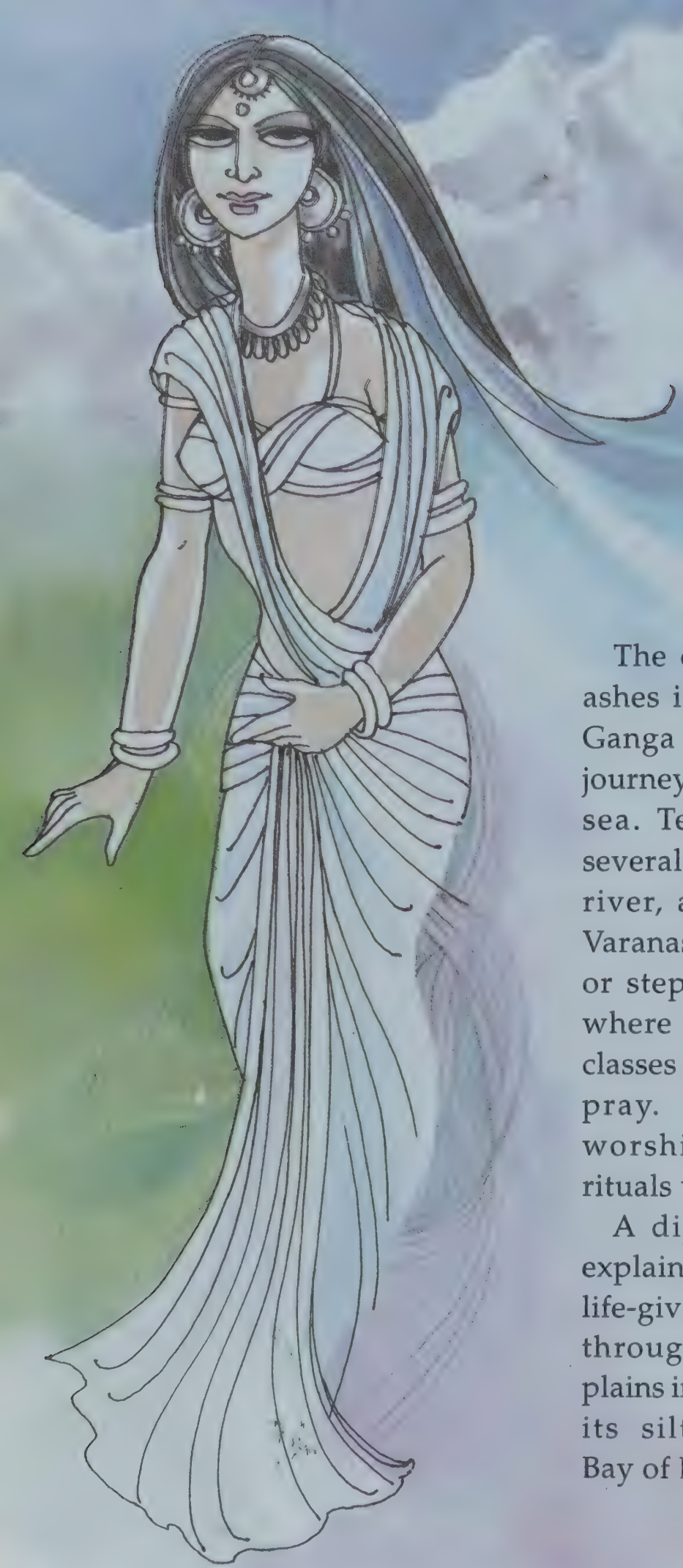
When Thailand's Buddhists offer food to monks for blessings, they pour water on the ground so that their dead relatives may share these blessings. Monks sprinkle water on their heads as well. At a Thai wedding, relatives and guests pour water from a conch shell on the folded hands of the bride and bridegroom by way of good wishes.

The Hindus revere water as one of the five elements that make the universe. When a new or renovated temple is ready for use, the images of its gods and goddesses are bathed in holy water. Hindu worshippers also sip holy water that the temple priest pours into their cupped hands, right palm over left.

It is little wonder that water has been revered from the remotest times. After all, what would happen if it did not rain or the river dried up? Countless myths, legends and folk tales grew around rivers, seas and rain. Handed down the generations, these have become an inseparable part of the texture of life. Water plays a central role in the rituals and festivals and ancient traditions that are carried on today with great spirit.

The Ganga

The Hindus worship the Ganga, and they have been bathing in its sacred waters for centuries to wash away their sins and diseases.



The devout hope to have their ashes immersed in the holy river Ganga after death, for their final journey and dispersal into the wide sea. Temples line the banks, at several places of pilgrimage on the river, as at the ancient cities of Varanasi and Haridwar. Here ghats or steps lead down to the water where pilgrims of all castes and classes crowd at dawn to bathe and pray. At dusk the river is worshipped through elaborate rituals with *aarti* and chanting.

A dip into Indian mythology explains the sacredness of this vast life-giving river. The Ganga flows through one of the most fertile plains in the country before pouring its silt-laden waters into the Bay of Bengal.

The Ganga was the beautiful though wayward daughter of Himavat, the King of Mountains, who lived in the heavens. Once, Brahma the Almighty promised that the Ganga would descend upon the earth as a reward for the sage Bhagiratha's amazing penance. Bhagiratha had remained in a forest of the Himalayas for a thousand years with his arms upraised amidst hot fires. He had asked Brahma to grant him a boon. The ashes of his ancestor King Sagara's sixty thousand sons lay far below the earth under a curse. Water, not of the earth, was required to flow over these ashes to purify them. Only then would the cursed souls attain heaven.

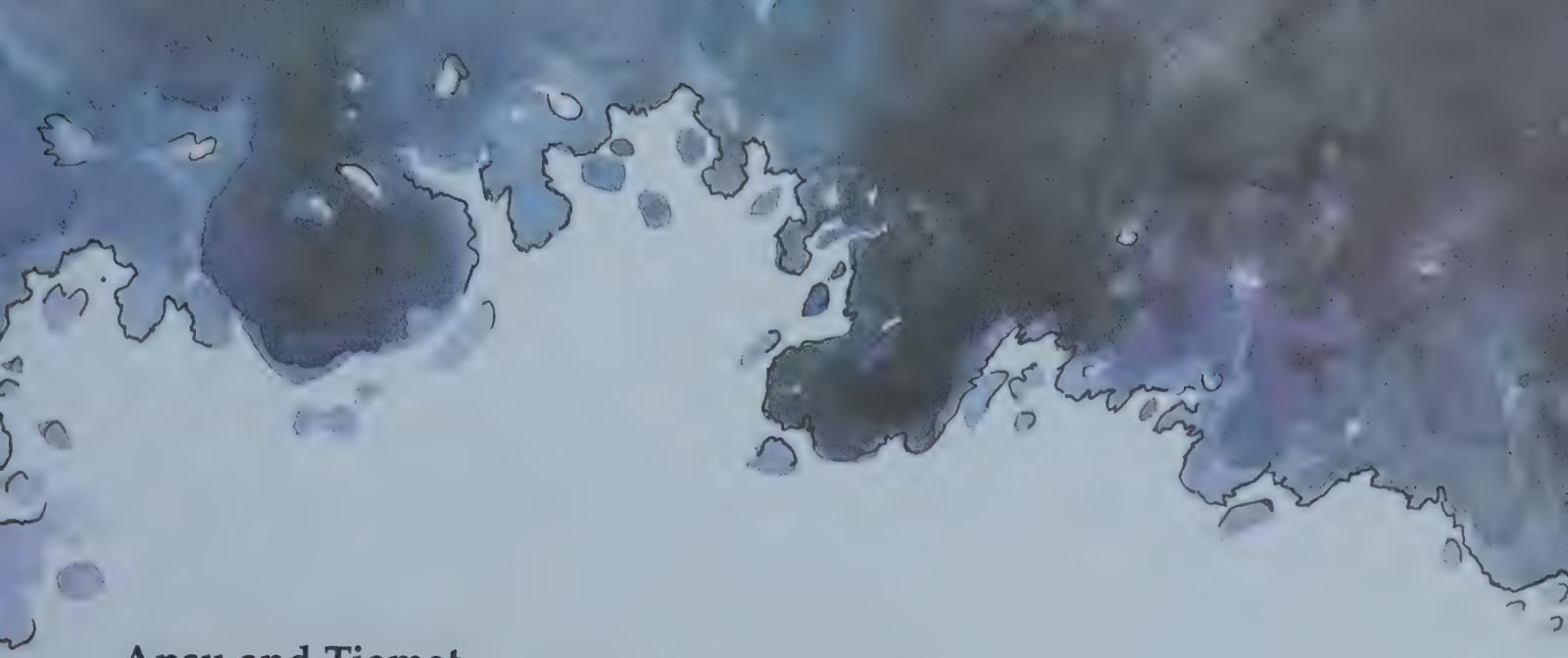
The Ganga could not disobey the command of Brahma, but she was reluctant to leave her heavenly abode. She decided petulantly to descend with such terrifying force that the earth would be dashed to bits. Bhagiratha was plunged in worry. Only one thing could break the force of her fall—Lord Shiva.

For a whole year the sage worshipped Shiva, who agreed to take the fall of the Ganga upon his head. Holding his trident aloft, he stood on a high peak and summoned the Ganga down. The imperious river was annoyed at being called thus and decided to sweep Shiva away. And so, she came earthwards in a mighty fall.

Shiva smiled. He would teach the arrogant Ganga a lesson! For seasons on end he made her streams wander through the long locks of his hair.

Ultimately, it was only after Bhagiratha fervently entreated Shiva to allow the Ganga to come down on earth that she descended in seven streams.

The gods came in their golden chariots to watch her magnificent descent. Sages and saints purified themselves in the hallowed waters that had wandered so long upon Shiva's head. As the middle stream flowed following the chariot of Bhagiratha, he led it to the wide sea where it sank to the middle of the earth to purify the ashes of King Sagara's sixty thousand sons. Rejoicing, these souls went to heaven!



Apsu and Tiamat

Tales of creation abound in the oldest civilizations. Sumerian mythology tells us that all beings, beginning with the gods, arose from the fusion of sweet water (Apsu) and salt water (Tiamat). From their mingled waters came forth first Mummu, the tumult of the waves, and then a pair of monstrous serpents, Lakhmu and Lakhamu, who in turn gave birth to Anshar, the celestial world, and Kishar, the earth. To them were born the great gods who peopled the sky, the earth and the underworld.

The new gods disturbed the peace of their ancestors, Apsu and Tiamat, who decided to get rid of them. A fierce army was summoned consisting of enormous serpents, dragons, monsters and scorpion-men. However, their plans were disclosed and Tiamat was killed by Marduk the Wise, with his chief weapon, the hurricane, accompanying his chariot. From Tiamat's body he refashioned the heavens and earth. He constructed a dwelling place for the great gods in the sky, and installed the stars which were their images. He moulded, too, the body of the first man, 'the seed of mankind'. Finally the great rivers, vegetation and animals were added. The work of creation was complete!

Enki (or Ea) was the water god. He was helped by his daughter, Nanshe, the goddess of springs and canals. Like her father, she was honoured and worshipped, and every year on a canal near Lagash there was a procession of boats to escort the sacred barge in which the goddess rode.

Poseidon, Indra

The mighty Poseidon was the Greek God of the sea, lakes and rivers. Even the earth belonged to him, for it was sustained by his waters and he could shake it at will, causing earthquakes. During his war with the giants, he split mountains with his trident and rolled them into the sea to make the first islands. He lived in a magnificent palace in the depths of the Aegean Sea. He would travel in a chariot across the watery plain, clad in shining golden armour. He was indeed the master. Sea monsters would rise from the murky depths to pay homage to their king, and the sea would joyfully open up before him, never wetting his chariot as it sped across the waves. Poseidon was usually accompanied by wild storms, which reflected his fury and rage.

The Romans identified Poseidon with their God Neptune who had power over the sea and seafarers. He could prevent or cause sea storms. The ancient Romans were a seafaring people and much of their food and necessities came by ship. So Neptune played an important role in their lives. Sea travel was dangerous in those times and Roman sailors would pray to Neptune for safe voyages. On their return home, sailors dedicated a valuable object to Neptune in gratitude.

His weapons are lightning and the thunderbolt, and his chariot is the sun. He killed the demon Vritra who prevented the monsoons from breaking. He can split mountains and send torrents rushing towards the sea. Who is he?

He is none other than the Indian Sky God, Indra and also the God of rain. As he gives both light and water, he is also fertility.

In a land where the soil is exposed to the burning sun for months on end till it becomes so hard that it cannot be ploughed or sown, the god who brings rain is invoked very often in flattering hymns.

In fact, the largest number of Vedic hymns are addressed to Indra. He reigns in the sky and triumphs in the storm when he thunders and lets loose rain.

One of our popular legends is the story of the churning of the sea when Indra was cursed by a great sage. Vishnu offered him mount Mandara as a stick and the snake, Vasuki as a rope to churn the sea of milk to yield *amrit* or the nectar of immortality. However, the gods (Devas) needed the help of their demon half-brothers, the Asuras, for the task.

They churned the sea for a thousand years while Vasuki spat out torrents of venom which threatened to destroy all creation. To save

the world, Shiva drank the poison and held it in his throat which turned blue in colour—Neelakanta.

At last the sea of milk began to yield its wondrous gifts—Surabhi, the wish-bestowing cow, Apsaras—the heavenly nymphs, gems and much more. Last of all came Sage Dhanvantari who held the coveted cup that contained the *amrit*!

The Asuras grabbed it from his hands and fled. However, Vishnu assumed the form of Mohini, the loveliest of nymphs, who fascinated them even while they argued with each other. He took the cup and brought it back to the gods. They drank the nectar and regained their lost vigour. The Asuras were driven away forever!

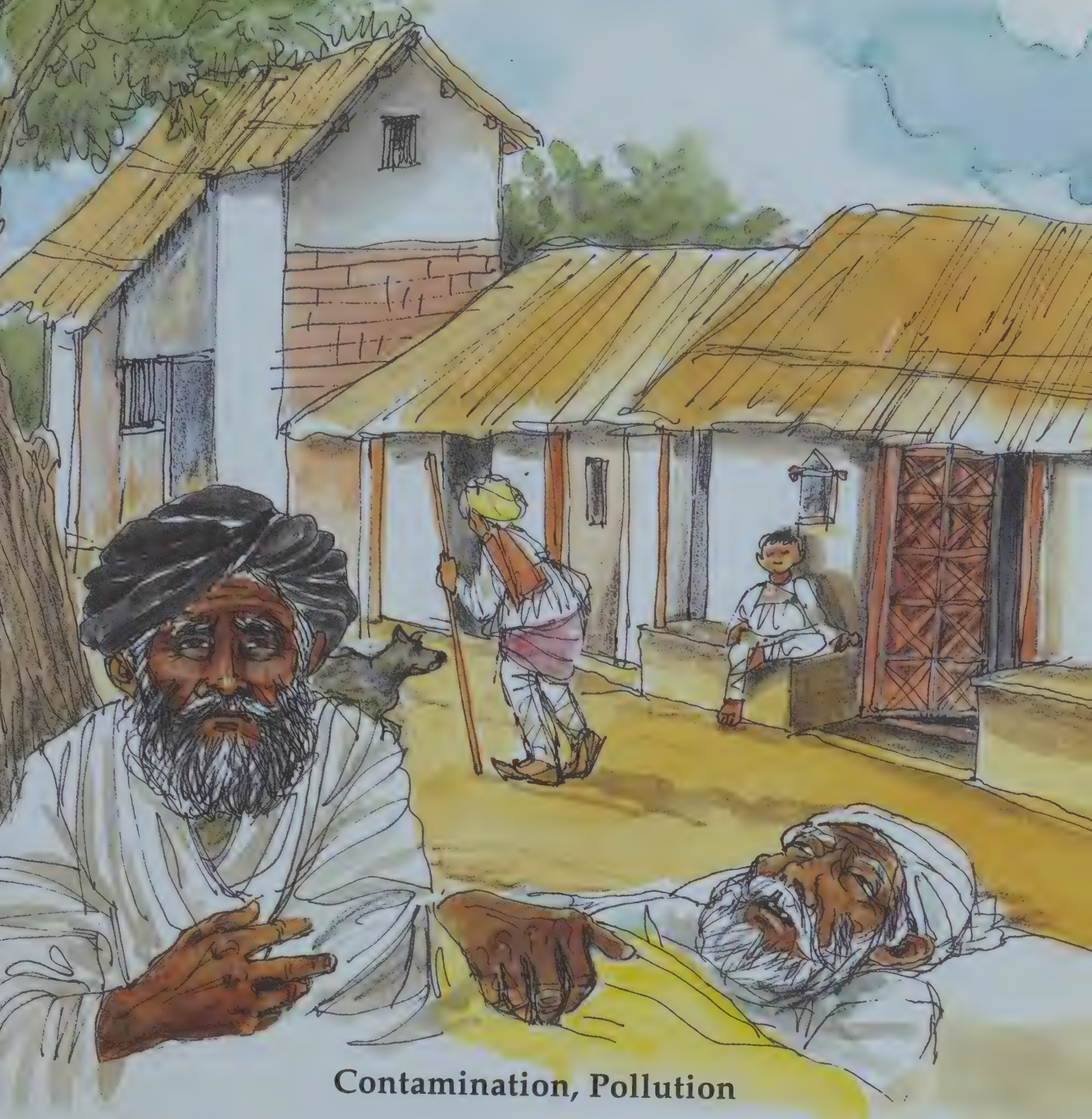
Cause of myths

Water lore, with wonderful tales of mythical sea creatures and mermaids, abound in all corners of the world. They explain many watery facts through interesting stories. For instance, why is the sea salty? The people in the Philippines tell us that the giant Angngalo wished to prove his love for the Goddess Sipnget. As white stone was scarce, he built her a palace of salt. But Taaw, the God of the sea, became jealous and swept it away into the water. That is why sea water is salty!

Water lore is full of fascinating figures, larger than life and often fearful. Down the ages such myths held people spellbound with wonder and interest, while imparting morals as they unfolded.

How did they begin? Some scholars believe that they were actual historical events that became distorted and took on supernatural colours with the passage of time. Others think they resulted from an attempt to explain natural occurrences that people could not understand through symbols. With time, their symbolic purpose was forgotten and people came to believe in the heroes and divinities.

Whatever the reason, for thousands of years these wonderful myths with their colourful characters provided material for much of the world's greatest art—they inspired masterpieces of literature, music, painting, architecture and sculpture. These are our real riches—the riches of our heritage.



Contamination, Pollution

Was the tiny village of Prempur in northern Gujarat under a terrible curse? Dhanabhai wondered as he writhed in agony on a string cot. He had lain here in his son's hut for over two years. His arms and legs were stiff and constantly swollen. Used to a life of hard labour on the land he tilled, he could not even sit or stand now. A terrible pain racked all his joints.

Dhanabhai shook his grey head sadly. Earlier, he had thought he was suffering from arthritis. Not only he but much of the village was victim to this strange illness.

Visitors to Prempur were struck by a terrifying sight. Many of the village's young men could not walk without a stick. In the village school, most of the children could not chew anything that was hard, not even roasted peanuts! Many complained of pain in their wrists and limbs. Dhanabhai's grandson, Mukesh, was hardly eight but his teeth were already turning black. Was the curse coming upon him too? Dhanabhai trembled in fear, and folded his hands in prayer.

Did an evil spirit reside in Prempur? Were the villagers suffering for the sins of their ancestors? Nobody seemed to know. Some said they had heard spirits at night at the edge of the village, wailing hideously. Others spoke in hushed tones about murky shadows that moved on the highest trees.

The villagers had tried to drive the spirits away through rituals and temptations of food. This having failed, even sticks were resorted to in an attempt to thrash them out of their hideouts. But the evil spirits did not go! A whole new generation was falling victim to the strange curse.

To add to Prempur's woes, this summer, as always, was long and dry. Hundreds of cattle died of thirst. Those from neighbouring areas, who could brave the searing heat, left the Kutch area with their cattle for south Gujarat in their quest for water. Skeletons of thousands of cattle dotted the way to Panoli. Countless tender calves died in agony, thirsting for water. The people of Prempur had to suffer in silence. There was nowhere they had the strength to run away to—far away from the village curse.

The story of the accursed village spread far and wide. One day social workers arrived on the scene. They brought with them some doctors from the nearest civil hospital.

"Bah," spat out Dhanabhai in disgust, when he heard of their arrival. "What do these doctors know? The spirit must be appeased to remove the curse on us all! Only then will the illness go away."

Fluorosis

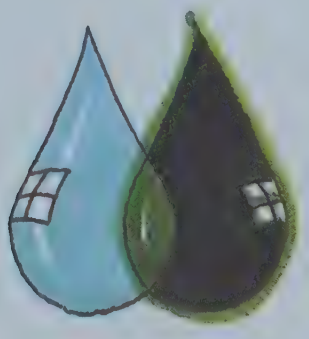
The doctors examined the village population. They took samples of water from the drying wells. Soon another team arrived from the distant city of Ahmedabad. They took more samples. They also asked the villagers many questions.

The verdict was astonishing. There were no spirits around. The villagers were suffering from fluorosis. The fluoride contents of the water from the village well had made every drop of water a drink of poison for the human body.

Fluoride are chemical substances sometimes added to water to prevent tooth decay. However, when water contains abnormally high levels of natural fluorides, as in Prempur, fluorosis destroys the human body. This crippling disease affects the spine and bones, which become soft and crumbly. Parts of the body stiffen and the victim becomes disabled and hunchbacked. In Gujarat and other states of northern India, thousands of people become old before their time, like Dhanabhai, because of fluorosis.

The tragedy here is twofold. Not only is there an acute water shortage, but the little water available is naturally contaminated with poisonous fluorides—even at a depth of two hundred feet.

If clean drinking water is not made available to these villages in northern Gujarat, much of the population here will become disabled and thousands of lives destroyed. The crippling agony of Prempur can only go on.



Water is the elixir of life. Yet it brings death to some, as in Prempur. Some years ago, West Bengal saw a similar tragedy, when naturally occurring arsenic compounds in the groundwater affected thousands of villagers spread over 34,000 square kilometres.

Water pollution has become one of our most serious environmental concerns. When it is caused by a natural hidden menace, the only recourse is to provide an alternate water supply. On the other hand, when we use ponds, rivers and seas as a giant dustbin, we wilfully destroy the benefits of the precious gift of water that has sustained us since life began.

Problem aggravated

The problem of pollution is not really a new one. It is as old as mankind itself. However, with the dramatic increase in population and industrialization, it has now taken on alarming proportions.

Today people need more and more water, electricity and goods. Factories and industries have spread considerably. In addition to their goods, they produce ever-increasing amounts of wastes—some of which are poisonous. These wastes are usually flushed away into water.

When garbage, sewage, toxic chemicals, metals, and oils from homes, industries, farms, and other sources are dumped blindly or washed thoughtlessly into water, it gets contaminated. Try mixing some household garbage in a bucket of water! Such water becomes totally unfit for drinking, cooking, washing and even manufacturing.

Industrial wastes contain many toxic chemicals that are discharged directly into water systems. At times industrialization gets us into hot water! Clean but heated water is often discharged by power plants into waterways. This is thermal pollution, which harms fish and aquatic animals by reducing the oxygen level of the water.

Pesticides, fertilizers and animal wastes too pollute water as it washes agricultural chemicals away from farmlands into streams.

Some of the oil that is carried in big ships called tankers spills into

the ocean water. Oil spills from offshore drilling rigs endanger marine life and destroy natural water habitats. What is more, offshore drilling and mining for minerals pollute seabeds and coral reefs as well.

What is more, dirty air can mean dirty water! The burning of coal, oil and other fuels by power plants, factories and smoke-spewing vehicles produces sulphur and nitrogen oxides. These come down with the rainwater, causing acid rain, which falls to the earth, and into streams and lakes, killing aquatic life. It also damages forests and soil, and even buildings and bridges.

Slow poisoning

Pollution thus touches water everywhere—in the rain that falls, in rivers, lakes, seas and the big oceans, and even in the water we cannot see beneath the surface of the earth. Pollution of groundwater is a serious problem, especially near cities and industrial sites where contaminated surface water, leaking sewage pipes and chemical spills all seep into the ground and pollute water supplies.

The poisons from the wastes get into the soil, and seep into groundwater, lakes and rivers—and finally into the ocean. It is not difficult to foresee what will happen in the future. The water of the earth everywhere will get dirtier and dirtier, and slowly all will be poisoned.

Sometimes improper separation of sewage waste water from clean drinking water causes serious water pollution. This can lead to the spread of deadly diseases like cholera, typhoid and dysentery, all common killers in our country.

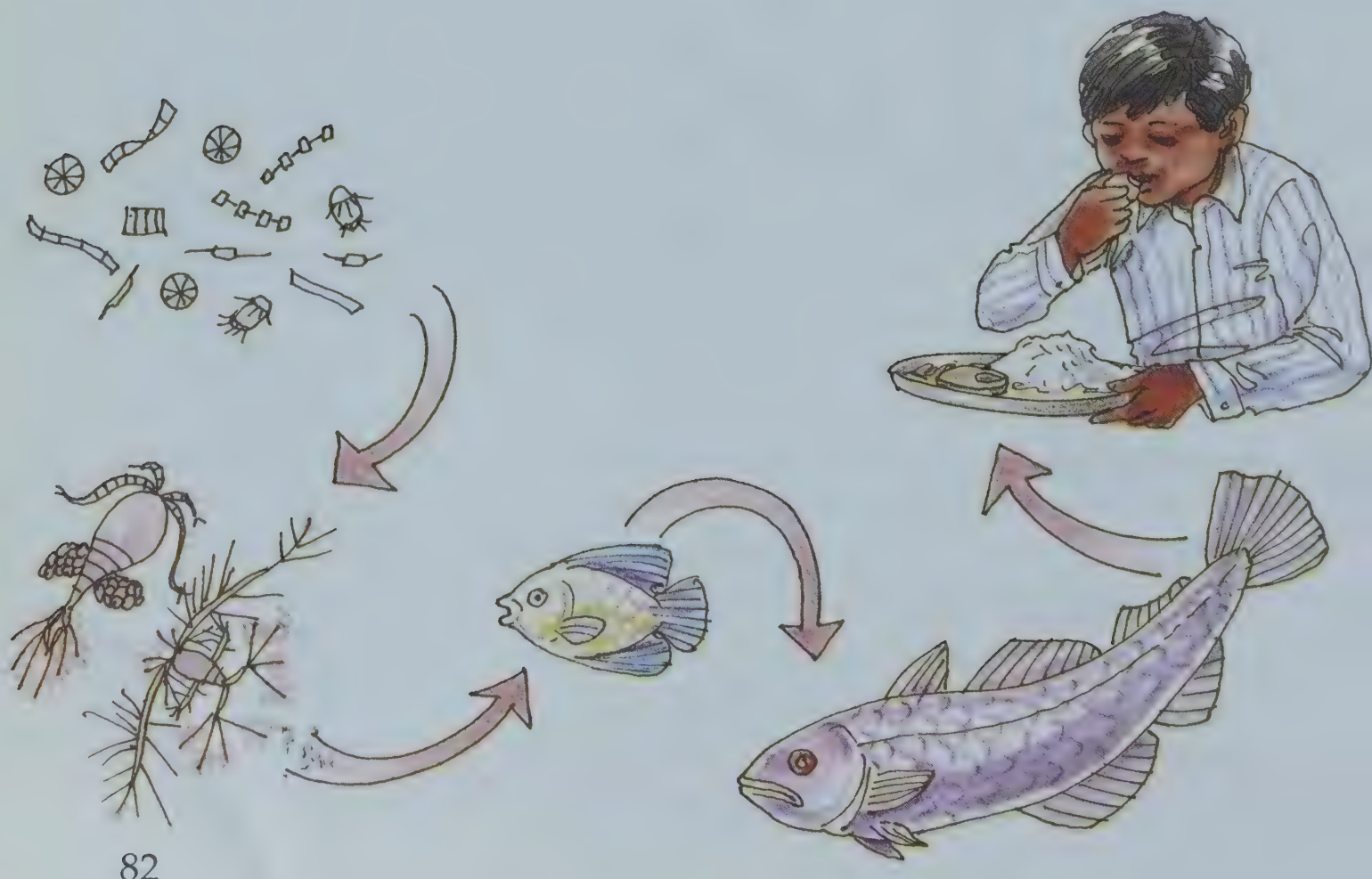
Often water may look clean but it contains germs, chemicals and other substances that cause sickness and death. According to the World Health Organization, about five million people die every year from drinking polluted water. It can also have devastating effects on many species of plants and animals. In fact, water pollution may result in the total destruction of freshwater life.

Clean-up process hindered

Nature has a great capacity to break down harmful matter and restore the balance so necessary for life to thrive. In a healthy water system, a cycle of natural processes renders wastes harmless, or even useful. It is interesting to understand how exactly this happens.

There are tiny organisms called aerobic bacteria which use the oxygen dissolved in water to digest wastes. In the process they release nitrates, phosphates and other nutrients, which are absorbed by algae and aquatic green plants. Microscopic animals called zooplankton eat the algae and in turn are eaten by fish. This fish may be eaten by bigger fish, birds or other creatures. When they die, bacteria break down their remains and the cycle begins all over again.

The problem occurs when the water is polluted so heavily that its natural cleansing processes cannot function properly. Certain wastes like oil, industrial acids and farm pesticides poison aquatic plants



and animals. There is every danger of the entire food chain being poisoned. Man would do well to remember that he is at the apex of many food chains, so much so that he cannot escape these poisons.

Wastes like phosphate detergents, chemical fertilizers, sewage, and animal manure pollute water by a reverse effect. They supply excessive nutrients for aquatic life and stimulate rich growths of algae. As more grow, more die too. The aerobic bacteria try to consume the excess dead algae and in the process use up large amounts of oxygen dissolved in the water. As the dissolved oxygen level drops, many aquatic plants and animals die. This process is called eutrophication.

A river will die when its pollution reaches such a level that all the dissolved oxygen is exhausted. It ceases to support life. Its waters become putrefied and a strong smell of decay fills the air.

Every year, industries across India contribute to over one-third of the poisons that pour into India's water systems. Stretches of innumerable rivers around industries are quite devoid of life.

Yamuna: a case study

There is nothing picturesque about the Yamuna any more as it flows into the capital city of Delhi. Water pollution here is taking on alarming proportions, and the river which is Delhi's main water source is fast becoming its river of peril. In fact, one could well agree with her description in Hindu mythology as the sister of Yama, the God of Death!

Delhi's water pollution record is indeed horrifying. With 430 million litres of untreated sewage, 20 million litres of industrial effluents and two billion litres of waste water discharged into it everyday, the Yamuna is merely a moving sludge. To add to this devastating situation, one million tonne of DDT (dichlorodiphenyltrichloroethane) flows in its stinking waters. Between the point where the Yamuna enters Delhi at Wazirabad in the north and leaves it at Okhla in the south, a distance of

just 25 kilometres, merely two per cent of its entire length and basin area, it collects 71 per cent of its total waste water! Interestingly, at Wazirabad the water is safe for drinking after treatment. But at Okhla, it is not even fit to bathe in because of the corrosive waste it contains.

The monsoon months are the worst, when the run-off from the farms is high and the bottom sediments are picked up by the fast-flowing water. The river literally turns into a sewer. The high concentration of pesticides in the water mean frightening diseases like cancer, neurological disorders and deformed babies. Latest studies show that chronic exposure to pesticides suppresses the immune system.

Upstream towns like Yamunanagar, Karnal, Sonepat, and Panipat in Haryana also dump their industrial effluents recklessly into the Yamuna. Downstream, Mathura and Agra add huge amounts of treated and untreated wastes, which accelerate the tragic process of degradation.

We have not spared even the holy waters of the Ganga. Abnormally high levels of industrial effluents are poured in at Kanpur, Varanasi and Patna. A massive project has been launched to clean the excessively polluted waters of this river which has been worshipped through the centuries for its purity and healing powers.

Everyday, hundreds of tonnes of filth is poured into the beautiful rivers of India. As industries mushroom alongside rivers, displacing the green cover and riverside population, the waters are poisoned by staggering amounts of chemicals, contaminating crops and fish, spelling disease and misery for the communities they earlier sustained. In addition, water-borne diseases like diarrhoea, viral hepatitis, typhoid and cholera are the main killers throughout the underdeveloped and developing world. These spread through contamination by sewage.

Rivers are highways to the sea. Any pollutants that are thrown into the rivers and lakes ultimately find their way into the ocean.

Oceanic disaster

The oceans and seas are vast, no doubt, and can absorb many pollutants from industrial wastes and sewage. But as a vast dustbin even they will not be able to absorb it all.

For instance, plastics dumped into the ocean form an especially dangerous group because they do not break down easily. They float on the surface, disrupting the environment of the microscopic surface-dwelling organisms. Many aquatic creatures mistake plastic items for food and die of choking as they block the digestive system.

A study has found that toxic elements are poisoning even the remote Arctic wildlife. Many chemicals, from pesticides to heavy metals, are banned or their use restricted in western industrialized countries. But large quantities are leaking into the atmosphere and the seas bordering the Arctic from industrial and military sites in the former Soviet Union, the U.S.A. and Canada. They threaten to deform and kill many beautiful species of seabirds, animals, fish and marine mammals such as the whale.

One of the worst instances occurred in 1987-1988 when over 750 bottlenosed dolphins along the U.S. Atlantic coast and thousands of seals in the North Atlantic died of unknown causes. It is believed these seals were exposed to lethal industrial chemicals.

Sometimes pollutants may not directly kill edible life in water. Chemical wastes discharged into coastal waters have accumulated in many marine organisms. They have contaminated the food supply of sea birds, animals and also humans. In some cases fish have become so toxic that people eating them have been poisoned.

Some years ago a Japanese industry on the shores of the Sea of Japan discharged dimethyl mercury into the sea. Mercury accumulated in the fish, and its concentration was enough to make them poisonous to man. All those who ate these fish suffered grim consequences. Many were painfully crippled and some died. Mimamata disease is the name given to the unique and horrifying illness caused by dimethyl mercury poisoning.

Oil spill

Intensified petroleum exploration and the use of supertankers capable of carrying more than 500,000 tonnes of oil have made oil spills on sea an increasing modern menace.

Oil, being insoluble, spreads on the surface as a thin film called an 'oil slick'. Drifting oil slicks have coated thousands of sea creatures, suffocating most of them, and littered beaches and coastal areas and harmed the environment irrevocably.

The giant oil tanker, TORREY CANYON, carrying 119,000 tonnes of oil for the British Petroleum Refinery at Milford Haven in the U.K., ran aground in the Channel in 1967. Crude oil began to flow out from her damaged tanks. In three days an oil slick, 56 kilometres long and 32 kilometres wide, spread towards Cornwall killing thousands of fish and marine plants below it.

Something had to be done fast! It was decided to bomb the ship and set fire to the oil. Within a week the Royal Air Force and the Fleet Air Arm dropped 161 large bombs and 55,000 litres of aircraft fuel. They succeeded in burning the oil on the ship, but the oil slick continued to spread. Desperate measures were taken to disperse the oil. Nine million litres of detergents were dropped from planes, but they could not prevent its reaching the coast as a length of 160 kilometres of the Cornish coastline was covered with black oil.

The consequences of the oil spill were disastrous. It has been estimated that thousands of seabirds were killed and countless other sea creatures wiped out. Rescuers cleaned nearly 6,000 birds, but many died of disease and shock. Worse still, it was discovered that the detergents had caused more damage to marine life than the oil itself! Experiments performed later on revealed that even a small amount of detergent killed 98 per cent of the creatures in a rock pool. In this case over 4.5 million litres had been used on the beach alone!

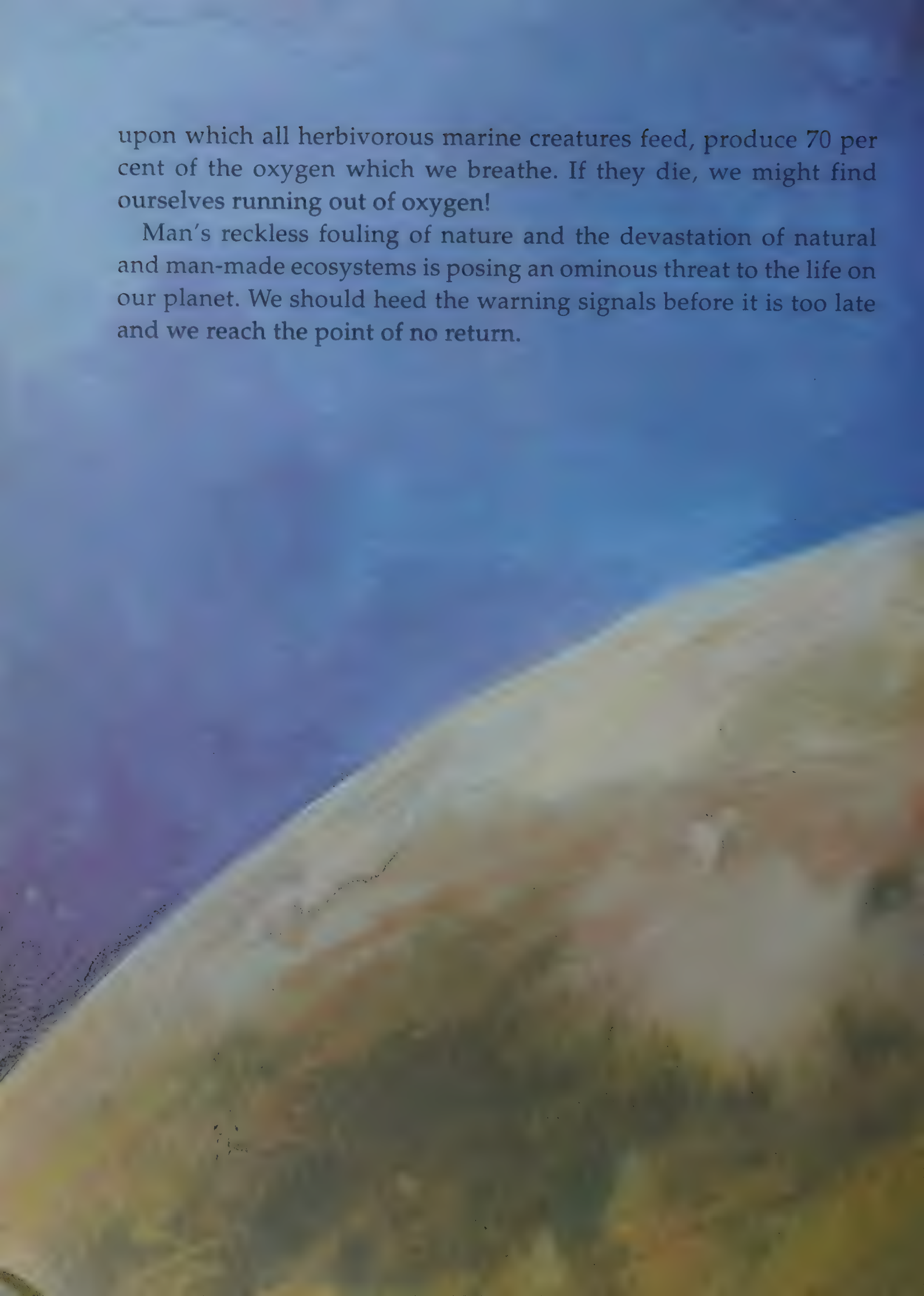
Toxic wastes

In 1970, some large rusty oil drums were being trawled by a fishing boat in the North Sea. One accidentally burst open when being swung on board, spilling its bright orange contents. Almost instantly, the entire catch of fish was killed. The poison was the waste of a plastics industry dumped into the sea. It was later found to be so deadly a poison that just 10 parts to a million parts of sea water would be lethal to animal life within. Some time later, in the same area, a belt of dead fish stretching almost up to 112 kilometres was discovered by a Norwegian ship.

Far more deadly things are being dumped in the oceans. Radioactive wastes from atomic power stations were regularly dumped in the Atlantic. In small amounts they do not kill fish, but do affect eggs and plankton. This would mean the death of all sea creatures who feed on this. Phytoplankton, the tiny plants of the sea

upon which all herbivorous marine creatures feed, produce 70 per cent of the oxygen which we breathe. If they die, we might find ourselves running out of oxygen!

Man's reckless fouling of nature and the devastation of natural and man-made ecosystems is posing an ominous threat to the life on our planet. We should heed the warning signals before it is too late and we reach the point of no return.



Saving Our Planet

Imagine, we are far in the twenty-first century. Many more centuries have passed. Our friendly alien from outer space feels the urge to see the 'Blue Planet' once again. The rain that falls, the beautiful rivers that flow are etched deep in his memory. His spaceship circles the solar system and he looks for it everywhere... but in vain. Has the planet that once hung in space like a sapphire blue globe vanished from the face of the universe? Disappointed, he slowly turns his spaceship away.

He has failed to recognize the 'Blue Planet'. It is still there, but its blue waters have turned a murky brown. What is more, it emits a powerful stench of death and decay. Its oceans and seas are vast chemical pools. They submerged the land when the planet heated up to melt all the ice caps. In fact, only a few islands remain. They were once towering peaks in the mighty Himalayan range.

Life had ceased to exist on this dead planet a long while ago. The chemical seas and oceans have throttled all marine life with their deadly toxins. As the waters died, the land died too. The poison has spread everywhere, up the food chain...right to its apex—Man. Then the melting waters came flooding down and washed away all his sins. Maybe in the remote future new life forms will appear and evolve in this strange chemical soup just as they did in the dawn of the earth's existence.

A scene from a science fiction film? A chilling nightmare? Or simply a grim portend of reality?

Man has already chosen his path. Maybe he is well on his way to destruction. In his thoughtless pursuit of power and comfort, will he pause to consider the dire consequences of his carelessness? Will he wake up in time to clean his mess?

A beginning has been made to save the earth with various anti-pollution programmes having been started. There is a growing awareness that indiscriminate dumping of wastes in water and illegal fishing should be curbed, marine and freshwater habitats preserved and endangered species protected. National and international efforts have begun to control pollution in waters everywhere.

Water has to be purified for domestic use before distribution in most cities and towns. Everybody needs drinking water that is sparkling clean, without taste or odour and free from germs. In its natural state, water seldom has these qualities. After it is drawn from a source it is piped into a treatment plant for purification. The plant may put water through one or several processes depending on the quality of the untreated water and on local standards. Usually, three basic processes are used—coagulation, filtration and sterilization.

It is a matter of serious concern today that water treatment plants are finding it difficult to cope with unforeseen pollutants like chemicals and metals. These are indiscriminately poured into water sources and cannot be removed by standard processes of water purification.

Many governments have now passed laws limiting the amount and kind of waste that can be dumped into water. A lot of money is

being spent on research and on water treatment plants to salvage this precious natural resource.

Enforcing standards

The U.S.A., like other developed nations, has designed standards to reduce the amount of harmful bacteria, chemicals and metals in drinking water. Here, the Environmental Protection Agency (E.P.A.) and state governments began enforcing these standards twenty years ago for about 240,000 public water systems throughout the country. The E.P.A. also surveys pollution levels in water and locates the sources of pollutants.

Industries today are being encouraged to reduce pollution by treating wastes to remove harmful chemicals before dumping them into water. Industrial wastes can also be reduced by using manufacturing processes that recover and reuse polluting chemicals.

After the issue of regulations by the E.P.A., many factories and power stations have made an attempt to reduce thermal pollution by cooling waste water in cooling towers before releasing it into rivers. Sometimes industries reduce thermal pollution by releasing hot water in scattered areas to prevent a dangerous temperature rise in any one place.

Where can one escape when even the rain that falls from the skies is acidic? Scientists and engineers have developed new ways to reduce the acidity of rain. Several devices remove sulphur and nitrogen compounds from fuel or industrial emissions before they reach the atmosphere. Adding alkaline lime to lakes, rivers and drainage areas temporarily neutralizes their acidity. But this has harmful side effects. The U.S.A. has taken a lead by amending its Clean Air Act, 1970, to reduce acid rain by tightening standards for emissions, requiring fuels that burn more cleanly and calling for power plants to cut their sulphur emission.

After London ceased to be Europe's largest port almost three

decades ago, the River Thames on which it stands, went into decline. From being one of the world's busiest waterways it fell into neglect. Vast areas of dockland were abandoned and used as storage space for old, rusty barges and cranes. What is worse, they became handy dumping grounds for industrial waste and sewage as well. Fortunately, the Government has now woken up and recognized the Thames as an environmental asset and an integral part of the British heritage. A master plan has been designed to clean and protect this river, and make it a living, working waterway once again.

World concern

The oceans do not belong to anyone. This makes it all the more important that we work collectively to find solutions to the problems of ocean pollution. By the 1970s, some nations bordering the North Atlantic passed laws restricting practices that pollute the ocean. Since then, most nations along the Atlantic have worked to reduce the pollution in coastal waters.

In 1982, the United Nations adopted the Law of the Sea Treaty which aims to limit ocean pollution. It cannot take effect until 80 nations sign it, but most of it is being followed already. In 1988, an international treaty banning the dumping of plastics from ships and other vessels came into effect. It was signed by several countries.

Oil spills can be messy and disastrous. Scientists and engineers have devised several methods to clean them up. A ring of floating devices placed around the spill prevents it from spreading. The oil is then pumped up from the water surface. Messy spills are sometimes cleared by placing sheets or particles of floating oil-absorbing matter on the ocean surface. Burning the oil or the use of detergents, as we saw, creates more problems.

Tankers are really the worst offenders. They spill about 1.1 billion kilograms of oil every year into the oceans as a result of accidents and normal ship operations.

Subsequently, under the Oil Pollution Act of 1990, all tankers must have a double hull to minimize oil loss in accidents. In case of oil spills, the shipowner must pay unlimited damages. Steps have also been taken to prevent discharge of oil into the sea which is carried in the deepest holds to stabilize ships.

India

Authorities in India are waking up to the dismal reality in a country where water pollution levels are many times higher than safety norms, and rank among the world's very worst. As industrial zones turn into disaster areas, the Central Pollution Control Board has stepped in to call a halt to industrial development in critically poisoned areas.

Patancheru in Andhra Pradesh was being developed into a kind of showcase for industrial development. For over a decade, 300 industries, mostly chemical and pharmaceutical units, came up in this rural backwaters—without even a sewage system. Today all the groundwater is heavily poisoned. Heavy metal concentrations are up to ten times above safe levels. As a result, chronic respiratory problems abound.

According to the Central Pollution Control Board, Patancheru is one of India's 22 most critically polluted areas. Strangely enough, the State Pollution Control Board ignored the situation till 1990, when irate residents appealed to the Supreme Court for help. It stepped in to stop all industrial development here. In 1997, the Court issued new orders for a massive clean up. This could take at least five years and a huge investment of rupees fifteen crores to begin to undo the damage.

Indeed the price we must pay to clean up is a high one. Most effluent treatment units cost between five per cent to 15 per cent of the total investment on industries like paper. The cost spirals from 25 per cent to 40 per cent for manufacture of consumer electronic

goods. Pollution control systems in power stations can cost as much as Rs. 1 crore for every megawatt of electricity generated.

In India, in the last few years more than 10,000 industries nationwide were either shut down, asked to move out of cities, or given an ultimatum to clean up the mess. The orders were issued by the courts which citizens approached in desperation and as a last resort. In addition, many large industries are being made to realize that proper scientific recycling of wastes can mean good business. All this heralds a rising awareness and concern, though much more must be urgently done.

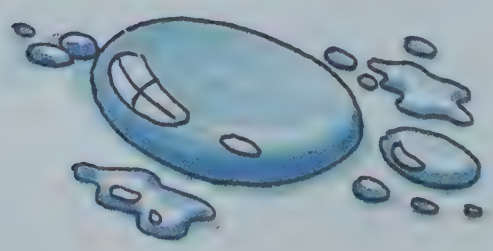
For instance, the big Indian cities and towns generate around 20 billion litres of sewage or waste water everyday, but treat only one-tenth! In fact the total sewage generated has increased six times in the last 50 years. The water requirement of major water-consuming industries like those based on agriculture, refineries, petrochemicals, fertilizers and chemicals has grown 40 times—but these do not treat the huge waste water generated.

Actually, the control of pollution has posed the most difficult questions of our century. Many serious pollutants are closely bound to vital agricultural or industrial systems or products. The banning of certain pollutants may involve the total redesigning of an industry or its products. This will necessarily involve an enormous expense and research.

Yet there is something that we cannot forget. We do not inhabit the 'Blue Planet' alone. Life on the earth is a harmonious coexistence, a kind of two-way partnership between us and other creatures in water and on land. We are all knitted together in an intricate web of food chains.

When we think only of ourselves and neglect or tamper with this web, we threaten a vital life support system. Unwittingly, we endanger our own existence as the earth chokes to death.

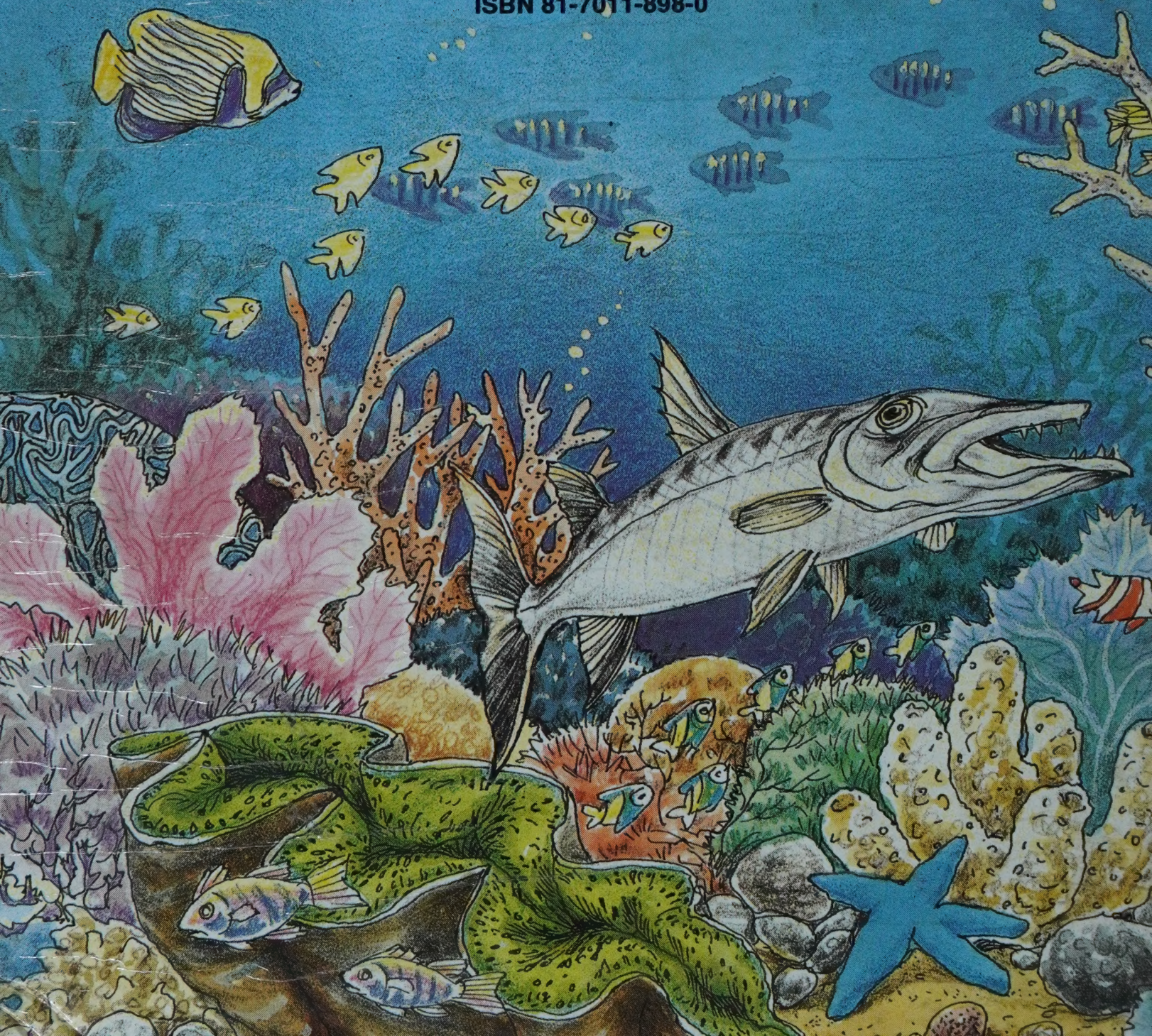
The waters that give life can also bring death. Hence the price we must pay to make amends for our negligence can never be high. It is the price we have to pay for our survival.



Shikshamitra
EDUCATION RESOURCE CENTRE
62B, Alipore Road, Kolkata -700027
Ph: 2479 9271

RETURN DATE SLIP

DUE DATE	DUE DATE	DUE DATE

We love it.
We benefit from it.
We take it for granted!
It is everywhere.
How well do we know this
shapeless thing that
sustains our lives?
A study.

Rs. 70.00
E 382
ISBN 81-7011-898-0